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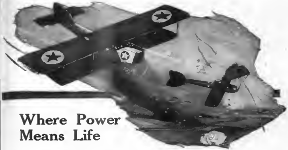

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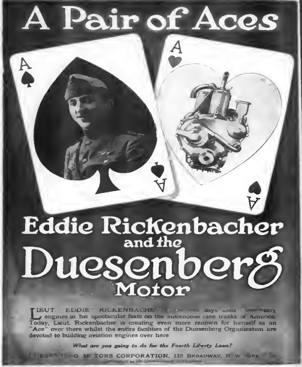

SEPTEMBER 15, 1918 **AVIATION AND AERONAUTICAL ENGINEERING** VOL. V. NO. 4

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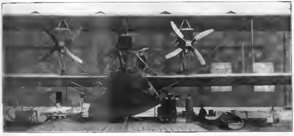
Vol. V September 15, 1918 No. 4

Transatlantic Flight by Airplane

By Frithiof G. Ericson, F. R. Ae. S.

When immediately before the outbreak of the war Glenn H Curtiss, and Lt Col Porte, R A F., were building the first twin-engined flying boat, the "America," which they intended to use in an attempt to cross the Atlantic, their aim was to larger number of such machines are now being manufactured in the United States as well as in Canada and it is very possible that it will be found necessary to deliver these machines by the air-route I will, however, leave this question for the time be-



A Possible Transatlantic Machine the Three-Engined Porte Flying Boat, Developed by the British Admiralty

design a machine especially suitable for such a trip. If the feat could have been accomplished at that time it would have been counted as an enormous achievement in the development of aviation, even if the machine after its arrival, as well as its engines, would have been useless for further or future work.

But the war has changed these conditions. Our main object for a trans-Atlantic flight now would be to make it possible to in such way deliver American and Canadian built machines in England and France. These machines would on arrival in England be fitted with necessary armament, etc, and upon completion of such work flown direct to the battlefront. This method of delivery would not only be the fastest, but would also to an enormous extent relieve the shipping problem.

If today our object were merely to cross the Atlantic as intended in 1914, this could most assuredly be accomplished with any of the giant flying boats which during the last year have been developed by the British Government Machines like the F-5 or the Porte boat would be able to make the trip with only one re-filling during the journey, if the flight were made during the most favorable weather conditions

Since the time the writer took up the question concerning the delivery of American and Canadian built bombing planes by air-route, a great demand for giant seaplanes for use in the defence of the English and French coasts has occurred A

ing and confine myself to the problem of delivering American and Canadian built bombing planes by air-route.

The Most Favorable Flight Route

The problem of crossing the Atlantic from Canada to Great Britain by airplane may, for reasons of convenience, be considered mainly under two heads, viz (A) the most favorable flight route, and (B) the airplane required

1 Geographical Considerations—For a flight across the North Atlantic one is afforded the opportunity of choosing between three more or less favorable routes, namely, a direct route which would necessitate a non-stop flight of over 1900 miles, and two routes which would afford several intermediate points of stoppage.

The direct, or All-British (A. B) route, which is geographically speaking the shortest of the three, leads from Cape Spear, near St John's, N F, to Valencia Island, Ireland, and involves a non-stop flight over the Atlantic of 1923 miles.

Of the two other routes affording intermediate points of stoppage one, which we shall call the Northern route, would lead from St. John's, N F, to Christian Sound, Greenland, thence to Reykjavik, Iceland, and from there to Lewis Island, in the Outer Hebrides. The total distance of this route is approximately 2300 miles, that is, 20 per cent, longer than the

A B route, only in lieu of a 1900-mile overseas flight there would be three laps of 940, 730 and 635 miles, respectively

The third route, which may be called the Southern route, leads from St John's, N F, to the Azores, and thence to Lisbon, Portugal The longest overseas flight on this route amounts to approximately 1200 miles, on the leg from St John's to Flores, the westernmost of the Azores, whence there would remain a short leg, of 310 miles, to St Michaels, the easternmost of the Azores, and one of 850 miles from St Michaels to Lisbon. The total flight distance of the Southern route would thus amount to 2360 miles.

In the above outline of the three possible flight routes across the North Atlantic only distances have been taken into account. If the cross-Atlantic flight were, particularly under present, war time conditions, simply a matter of the shortest overseas flight involved, one should have no hesitation whatsoever to pronounce the Northern route the most favorable of all those considered

Unfortunately, in examining the possibility of a cross-Atlantic flight, one cannot pay attention exclusively to geographic conditions. Political and meteorological considerations needs also require careful examination

2 *Political Considerations*.—Political considerations are distinctly unfavorable on the Northern route, and are not entirely satisfactory on the Southern route

The Northern route involves points of stoppage lying in territories belonging to the Danish crown, namely, Greenland and Iceland, although the latter has more recently manifested its strong desire for separation from the Mother Country

Though it may be taken for granted that our transatlantic airplanes would carry no offensive armament, and should therefore possess the status of merchantmen, it seems more than likely that Germany would send strongly worded protest notes to Denmark should British aircraft use Danish soil for refueling, this in view of the fact that our machines would be manned by military crews, and that their ultimate destination would be distinctly hostile to Germany

It must be therefore presumed that the Danish crown would not consent to our intent of using Danish soil as points of stoppage for the proposed cross-Atlantic flight, and this consideration puts the Northern route virtually out of question for our purpose

The Southern route is much more favorable from the viewpoint of international politics, for the mid Atlantic point of stoppage as well as the European port of arrival both lie in territory of our Portuguese Allies.

A somewhat serious drawback may, however, be found to this route owing to the fact that our airplanes, on arrival in Portugal, would have to complete an additional overseas flight of some 800 miles in order to be delivered on British or French soil It would quite obviously be the proper thing to fly our machines from Portugal to France in an air line rather than have them accomplish a circuitous route via the British Isles or Brest Unfortunately, the strict neutrality of Spain will more than likely interfere with our endeavors to fly British aircraft across her dominions

Therefore, unless we accept the handicap of flying our machines from Portugal to Great Britain or France, the Southern route seems rather out of the question as a practical proposition If it should nevertheless be chosen, then a switch-line might be introduced at the Azores, which would lead from St Michaels to Vigo, Spain, the overseas distance of the third leg would thereby be increased to 927 miles, but the total distance to be flown to British soil would materially be shortened, and amount to 576 miles, with a longest overseas flight, from Cape Vilano to Ushant Island, of 413 miles. This was the route Lieut Col Porte, R A F (then Lieutenant, R N) proposed to fly in 1914 The total distance from St John's to Plymouth, England would, over the Southern route, then be 3013 miles.

Meteorological Conditions

3 *Meteorological Conditions*.—For an aerial crossing of the Atlantic it is of primordial importance to pay the closest attention to the meteorological conditions prevailing on the route chosen for this purpose. If one considers that a following wind of 20 miles per hour would add 480 miles to a day's flight, the importance of possessing a precise knowledge of the meteorological conditions which prevail in the Northern Atlantic becomes self-explanatory, for this may really be one of the most important factors in determining the success of our enterprise

The weather in the North Atlantic is largely governed by the tendency, more or less constant all the year round, to a low pressure trough lying between Greenland and Iceland, and a high pressure area which is permanent, although varying in extent, near the Azores

The low pressure trough generates the nearly constant cyclone storms which blow from a southwesterly quarter in the ocean areas extending south of Lat. 60° N to Lat 40° N while the high pressure area produces the anticyclone, or trade, winds which blow from the Iberian Peninsula toward the Antilles, passing south of the Azores

Consequently, over an ocean area of twenty degrees there is a more or less constant southwesterly drift of air, which would naturally be instrumental in increasing the independent velocity of our machines flying from America to Europe, and would correspondingly be unfavorable to a flight in the opposite direction

The intervening miles of sea in these latitudes—which embrace all three possible routes, though the A B route, lying approximately in the centre of this area, appears particularly favored—are peculiarly susceptible to great eddies of wind and rainy or snowy weather, sometimes extending as much as a couple of thousand miles in diameter. These cyclone storms move up from the Gulf of Mexico skirting the coast of Newfoundland, and proceed over the Northern Atlantic toward the British Isles, Scandinavia and Russia, where they gradually decrease in intensity

The late Prof L Rotch, founder of Blue Hill Observatory (U. S A), conducted for a great number of years a series of aerial soundings which enabled him to determine with remarkable accuracy the aerial currents which prevail over the North American Continent and part of the Northern Atlantic. His observations, which have been published under the title of *Charts of the Atmosphere* as well as the aerological data gathered by the Observatory of Manchester (England), would appear to furnish a sufficient basis for plotting the most favorable course for aircraft intending to cross the Atlantic

Professor Rotch himself suggested in 1912 two such routes, one in an easterly, and one in a westerly direction. His eastern route subdivides into two courses The first, from Lat 47° N, Long 53° W, to Lat 42° N, Long 30° W, a distance of approximately 1000 miles, the second, from Lat 42° N, Long 30° W., to Lat 52° N., Long 14° W, a distance of about 800 miles.

On the first course one-half of the prevailing winds blow from a westerly quarter with a speed of 21 m p.h. while on the second course three-fourths of the winds blow from the same quarter at the rate of 28 m p.h. These wind velocities were obtained by proof by Prof Rotch on correcting the data of the Pilot chart of the North Atlantic for July to the level of 1000 meters (3300 ft) by the average change in velocity and direction of these winds as found at the Blue Hill Observatory

From this study it may be seen that the A B route would have the great advantage of being situated within the area of maximum intensity of the eastbound Atlantic storms, whereas the Northern and Southern routes would be only on the outer fringes of this cyclonic belt. It follows that an airplane steering the course of the A B route and particularly that plotted by Prof Rotch, should be able to derive a maximum acceleration disposable from atmospheric conditions prevailing in the North Atlantic

The A B Route Favored

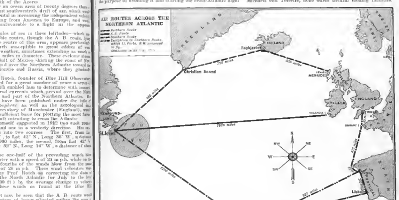
Consequently, in addition to the political considerations dwelt upon above, the A B route, leading from Newfoundland to Ireland, also appears to be the most favorable from the viewpoint of the following wind, upon which factor the success of the cross-Atlantic flight is dependent to a very considerable degree

4 *The Great Fog Bank*.—Another factor of this problem which should not be considered any too lightly is furnished by the vast fog bank which exists in the summer months over Newfoundland Bank for a distance of about 300 miles off shore The fog bank is particularly dense in the month of June, when the icebergs, on drifting south of Baffin Bay with the polar current, reach the Gulf Stream.

While the vertical depth of this fog bank is an unknown

factor one may assume that its extent is not such as to prevent airplanes from flying through and over it without expending an undue amount of gasoline in climbing Nevertheless, the very existence of this fog bank constitutes rather a serious difficulty, which it would be well not to underestimate, for a dense fog might cause the pilot to totally lose his bearings, therefore one believes it advisable that our transatlantic airplanes should avoid the area of this fog bank as far as is practically feasible

As this fog bank extends from Newfoundland mainly in an easterly and southeasterly direction, it would appear that for the purpose of avoiding it and starting the cross-Atlantic flight



under favorable conditions of visibility a machine heading for Ireland should steer for a hundred miles or so a northeasterly course on leaving Newfoundland

If such a course were steered at a certain altitude, it would not materially add to the flight distance to be covered because the higher the altitude, the more the wind tends to turn to the right, owing to the rotation of the earth For instance, if there is a westerly wind blowing near the ground then at 5000 feet the wind would probably be WNW, and at 10,000 feet probably NW

On the other hand attention should be paid to the Buys Ballot law, which is to the effect that the circulation in the northern hemisphere is clockwise in the low-pressure, or anticyclone areas, and anti-clockwise in the low pressure, or cyclone, areas. It follows that an airplane desiring to fly in an easterly direction *without climbing* would have to steer a southerly course at first.

5 *The Azores*.—If the competent authorities should decide that the Southern route is the most desirable of the three routes proposed, and that the drawback of the longest total flight distance is more than compensated for by the shorter overseas flights, then it seems necessary to give in brief the topography of the Azores, which would serve as a mid-Atlantic point of stoppage on this route

The Azores comprise a group of nine major islands, five of which are situated in a central group, while the remainder, grouped in pairs, form the western and eastern outposts of this archipelago The islands are all of volcanic origin, and present a very much cut-up and mountainous appearance, with the exception of two of the larger islands, namely St Michaels and Terceira, none offers natural landing facilities.

Violent thunderstorms are furthermore of common occurrence more or less all the year around, but particularly in the winter months, and the prevailing winds are so strong as to prevent the trees from reaching normal height While there are, as a consequence, no real woods, much shrubbery and undergrowth is to be found

Directional Reliability

It may be gathered from the above that the Azores do not offer a very suitable relay station for the cross-Atlantic flight.

6 *Directional Problems*.—One of the most difficult problems attendant upon the successful crossing of the Atlantic by airplane is admittedly that of affording the pilot a reliable means for steering a true course.

It is a well known fact that while the compass of an airplane may point the true course, yet the airplane may, by the agency of a cross wind, drift out of its course to a very considerable extent without the compass indicating this fact

To correct the resultant error in aerial navigation, various

apparati have been developed which purpose to indicate the magnitude of the drift, enabling thereby the pilot to fly a true course. One of the most successful apparati of this kind is the Sperry Synchronized Drift Set, which operates upon the principal of the stroboscope.

This apparatus, besides indicating the angle of drift, that is, the angle between the apparent and the actual direction of flight, is synchronized by mechanical means with the compass, so that the latter actually shows the true course without requiring manual adjustment to the reading of the drift indicator.

The only objection that might be made to the Sperry Drift Set is that its operation requires the observing of the direction in which the wave crests are travelling. This apparatus consequently falls short of its object in foggy weather, when an airplane flying at a level of several hundred feet may not see the sea at all for a considerable time.

Therefore, while the Sperry Drift Set should undoubtedly be carried on board transatlantic airplanes, it would seem necessary to supplement it with an instrument that would indicate to the pilot his true course even in foggy weather. This requirement appears to be satisfied by the use of directional wireless.

It is asserted that a radio direction finder can be obtained in the United States which instrument weighs less than 100 pounds and possesses a range of close to 1500 miles. Unfortunately it has not been possible to satisfy ourselves as to the reliability of this instrument, or as to whether it has ever been put to practical use.

But to our mind it does not seem indispensable for the success of the cross-Atlantic flight to have our airplanes fitted with instruments powerful enough to receive radio directives from two land stations, say the Azores and the Irish Coast.

We strongly believe that to prevent the airplanes from drifting out of their course it would be entirely sufficient to establish along the A. B. route a chain of suitable vessels—a kind of particularly sturdy pilot cutters—stationed, or, rather, cruising every 100 or possibly 150 miles from Newfoundland to Ireland.

Since the direction finders now in use on Allied and enemy aircraft have an effective range of 150 miles at the most, the trans-Atlantic airplane fitted with such an instrument should have no particular difficulty in keeping in constant touch with the pilot cutters and receiving radio directives from the latter.

This scheme would necessitate the permanent stationing of twelve or eighteen pilot cutters in the Northern Atlantic, and would obviously entail a considerable expenditure. It seems, however, that if the cross-Atlantic flight is to become, instead of a mere sporting venture, a systematized service for the purpose of delivering American airplanes to the front via the shortest route available, nothing short of the above scheme will have to be put in practice.

It should also be realized that the stationing of pilot cutters every 100 or 150 miles between the termini of the A. B. route, would also fulfill the valuable purpose of assisting in saving the crews of such machines as may have to alight on the Atlantic on account of engine failure, and, possibly, of salvaging the most important part of the airplane.

The Airplane Required

General Considerations.—In considering the airplane required for crossing the Atlantic, particularly on the A. B. route which the foregoing considerations apparently indicate as the most desirable of the three routes considered, it is first necessary to decide upon the type of machine which would possess the most favorable features for such an undertaking.

It might seem, in view of the nature of such a flight, that a large seaplane fitted with a convertible undercarriage would afford the most promising solution for crossing the Atlantic, for such a machine could be fitted with floats for the overseas journey, and, having reached its destination, its undercarriage could be converted for over-land use.

It is unfortunate that the flying-boat, though it possesses much greater seaworthiness than the float-type seaplane, cannot at present be considered in our plans, and this for two reasons.

Firstly, the radius of total flight weight to useful, or disposable, load of the flying boat is considerably inferior to that of the float type seaplane, and a *fortiori*, to the land-going airplane, all other things being equal. This is principally due to the considerable weight of flying-boat hulls, the weight item being caused by the necessary sturdiness of these hulls for ocean service, lacking which these machines could not withstand the pounding of heavy seas.

It is obvious, that for an undertaking of this sort the carrying capacity of an airplane would have to be taxed to its utmost limit, and that every pound saved in the weight of the structure could, and should, be employed for increasing by so much the flight endurance of the machine. Taking average figures, it may be stated that while a well designed land-going airplane will carry as much as one-half its flight weight (fully loaded) in disposable load, flying boats seldom are capable of carrying a disposable load much in excess of one-third the total weight.

Secondly, the structural features of flying boats being fundamentally different from those of land-going airplanes, it would prove well nigh impossible to convert flying boats for over-land use. this would naturally defeat the main purpose of our plan (i. e. the supplying by air of powerful bombing squadrons for use against Germany and Austria) and would limit the usefulness of our cross-Atlantic machines to the function of acting as auxiliaries to the Allied naval forces.

It follows that the flying boat type should, for the present time at least, be taken out of our calculations for achieving the crossing of the Atlantic.

There remain then to be considered the float-type seaplane and the land-going airplane. As against the latter, the seaplane has the advantage of affording a materially greater amount of safety to the crew, should the machine be compelled to alight on the sea on account of engine trouble, for the seaplane might float, even in a rather heavy sea, long enough to enable the pilot cutters to come to the rescue.

An ordinary land-going airplane, on the other hand, would obviously sink in a very short time so that the chance of saving the aviators lives would indeed be very slim.

However, in selecting the float-type seaplane as the type of machine most desirable for crossing the Atlantic, it should be borne in mind that the floats of the seaplane undercarriage constitute a not immaterial item of weight, so that the all round performance of such a machine must perforce be inferior to that of an airplane fitted with a wheeled undercarriage. As far as the disposable load of float type seaplanes, particularly of larger types, is concerned, this is somewhere between that of the flying-boat and the land going airplane, that is, about 35-40 per cent of the total flight weight.

It would, therefore, seem advisable to dispense with the floats entirely, if this could be done without putting in positive jeopardy the safety of the aviators and rather seek a solution tending to make a land-going airplane capable of floating a certain length of time.

This might be achieved by fitting the undercarriage and the tail of a landgoing airplane with bags made of air tight cloth which could be inflated from bottles of compressed air carried on board, and operated from the pilot compartment. Should the pilot be compelled to alight on the sea, the air bags would keep the machine afloat for a sufficient length of time to enable the crew to be rescued by the pilot cutters.

Such an arrangement will be found hard to dispense with if either the A. B. or the Southern route be adopted for crossing the Atlantic, because—as will be shown hereafter—the greatest flight endurance that may be incorporated in a machine is still so limited as to require a very careful husbanding of all non essential weights.

Propulsion

Propelling Apparatus.—The apparently most desirable type of cross Atlantic airplane having thus been elucidated, one may now turn toward examining the general lines of the problem presented by the propelling apparatus. This is really a very important problem, requiring the most careful planning, since it may in the end directly determine the success or failure of the undertaking.

That the cross-Atlantic airplane should be fitted with more than one engine is self-evident if one takes into consideration the possibility of a breakdown, which may occur with the best available engine. One is thus led to consider the twin engined machine.

Twin-engined airplanes do not, however, seem a very desirable type for crossing the Atlantic because of the unfavorable aerodynamic features involved in flying such a machine on one engine only. Indeed, if a mechanical breakdown, or the necessity of saving fuel, should compel the aviators to fly part of the journey on one engine only, then the off-centered pull of

the running engine will require a corrective setting of the rudders which will cause an appreciable increase in drag, and a corresponding slowing down on the flight speed.

In view of these considerations it would seem that the three-engined airplane really offers the ideal solution of this problem. Such a machine might be fitted with either two eccentric tractor screws and a central pusher screw (like the Caproni biplane, for instance), or else with two eccentric pusher screws, with the engine in separate housings, and a central tractor screw, fitted in the nose of the main body.

With this arrangement, by cutting out *any one* engine the power would be reduced but one-third, as against one-half for the twin-engined machine, while if either eccentric engine be cut out the off-centered pull would be reduced in the same proportion.

In a four-engined machine the location of the engines is a more difficult matter. In the giant Curtiss triplane flying boat "T" the engines were placed on one line, but this idea is not recommendable, as the two outside engines will have to be placed so far out that they will to a great extent interfere with the lateral balance of the machine.

As a further development of the advantages resulting from the principle of having odd-numbered engines one conceives a five-engined airplane having three tractor bodies, which would carry the tail plane and two pusher bodies fitted in between. The greater splitting up of the power plant into independent units would naturally increase the value of this scheme, though there would be also a certain increase in dead weight, as well as body drag, due to the existence of five independent bodies.

The Complement.—The complement should be made up of not less than four officers and men. Two of these should be pilots and expert navigators, while the rest should be air mechanics familiar with wireless operation. Since the pilot who flies the machine could not efficiently attend to navigation and wireless both, and the other pilot should rest in the meantime until the turn of his "watch" came, it becomes obvious that the radio operators must be other members of the complement than the pilots. Here again, for the sake of efficiency, it seems highly desirable to have two rather than one wireless operators on board, so they may take their turn at the key.

The Question of Flight Endurance.—Now that the general terms of the cross-Atlantic flight problem have been set down, one may examine the most delicate part of the project, namely the determining of the maximum flight endurance of a theoretical airplane.

As a matter of fact there are only two factors which fundamentally influence this problem, these are the efficiency of the airplane *as a whole*, and the efficiency of the air screw. If in a general computation of this kind we were to consider only the wing efficiency proper, that is, the lift drag curve of the most suitable aerofoil, we would obtain somewhat misleading figures, for we would not know the values of body and tail drag, nor the values of the additional friction resistance generated by the engine housings, the undercarriage, the struts and stays, etc., etc.

To determine the efficiency of a theoretical airplane as a whole one must resort to empirical methods, that is, one must determine the efficiency coefficient of a great number of successful machines and then take the average obtained for a given type.

ANOTHER TRANSATLANTIC POSSIBILITY: THE THREE-ENGINED CAPRONI TRIPLANE
Photo Press Illustrating Service

Following this rule it will be found that the maximum distance a theoretical airplane may travel on its own fuel is approximately 1200 English miles.

Conclusion

The foregoing considerations lead one to the following conclusions regarding the possibility of crossing the Atlantic by airplane.

(1) The political and meteorological factors are most favorable on the A. B. route, and, in order of merit, less favorable on the Southern and Northern routes.

(2) Given the present aerofoil and air screw efficiency, it appears impossible to build an airplane that will have a flight endurance greatly in excess of 1200 (English) miles. The aerodynamic factor is therefore distinctly unfavorable on the A. B. route (which requires a non-stop overseas flight of over 1900 miles).

(3) If it is nevertheless intended to send the airplanes across the Atlantic over the A. B. route, then the best way to achieve this undertaking is to use land going machines fitted with floating bags in connection with specially constructed aerodrome ships of very large size, and capable of keeping station under their own power.

(4) The plan to create aerdrome ships and maintain them permanently in mid-Atlantic would naturally involve a very considerable expenditure, while it would not absolutely ensure the success of the undertaking. Though it might prove easier to land on such a ship with a moderate sea, and then take off similarly, in a storm the landing difficulties would be greatly increased, though they would surely not approach those that may be encountered on attempting to alight with a flying-boat in an Atlantic storm.

(5) Should the plan to construct one or two aerodrome ships

be favorably considered, one might observe the following. The ships should be fitted with Diesel engines (to cut down obstruction and increase cargo capacity) of sufficient power to develop a speed of 5-6 knots, this should enable them to keep station in most of the weather they may encounter. Using two hulls joined together by a platform somewhat in the style of a catamaran would most likely prove successful. The platform should offer a landing area of at least 600 by 150 feet clear, and the ship should be protected against submarine attacks by internal construction, Bullivant nets, suitable armament, and possibly a number of patrol boats, as well as scout planes. The latter might also be of great assistance in locating machines which have lost their course or have been disabled.

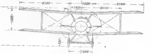
(6) The maximum flight range of a practicable airplane, 1200 miles, corresponds approximately to the longest overseas journey required on the Southern route. By throttling down the engines in proportion to the lightening of the airplane due to fuel consumption it should be possible to extend the flight range by some 150 or 200 miles, so that a certain safety margin would become available to take care of incidental detours, such as due to fog, storms, etc. It should, however, be noted that this margin is rather small to insure the success of a regular airplane route across the Atlantic.

(7) If, in spite of the unfavorable political factor the Northern route be chosen for crossing the Atlantic, it would really seem materially less difficult to insure the success of this enterprise. In those latitudes heavy storms constitute a much greater problem than fog, low visibility must also be taken into account, but since these storms blow mostly from a western quarter and no flight should be attempted without careful weather forecast being available, the drawbacks of this route seem more apparent than real. Low visibility should neither prove an unsurmountable obstacle, since navigation will be by compass. A real source of danger may, however, be found in the violent upward and downward gusts, and cyclonic whirlwinds which are frequent in these latitudes. Against all these drawbacks one must consider the very serious asset of the longest overseas distance, which amounts to only 940 miles, which comes to say that the theoretical airplane here considered would have a safety margin of over 33 per cent. The latter fact outweighs in our estimation the various objections that may be made against the desirability of the Northern route.

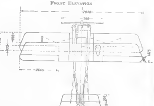
The D. H. 5 Pursuit Biplane*

The D.H.5 pursuit biplane herewith described was built by the Darracq Motor Engineering Co., Ltd., London, and bears the identification mark A 9435. It is a tractor biplane with a single pair of interplane struts on either side and with the wings set at a negative stagger of 0.695 m.

Both wings have a span of 7.84 m. and a chord of 1.375 m. The upper wings are fixed to a center section, while the lower wings are joined to wing roots at the height of the lower bottom longitudinals. There is no sweepback, but both wings



Front Elevation



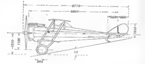
Plan

have a dihedral of 172 deg., the angle of incidence of the upper wing is 2 deg. amidwings and 2½ deg. at the tips, while that of the lower wing is 2½ deg. throughout.

* Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt.*

The wing spars are of spruce and of I-section. The ribs are spaced from 280 to 350 mm., and between each two ribs there are two false ribs, reaching from the leading edge to the front spar. The interplane and cabane struts are made solid of spruce, and the flying and landing stays are of streamlined wire.

Ailerons are carried on both wings, hinged to the rear spar.



Side Elevation

The control leads, of streamlined wire, run outside the planes, below in front of the leading edge, and above, over the front spar.

The body is of the ordinary four-longitudinal type braced by cross wiring, and is strengthened, in front, up to the pilot

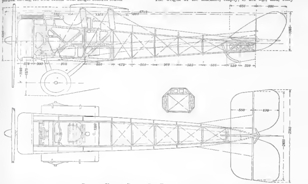
Three-Quarter Front View of the D H 5
From the Aeroplane

seat, and at the rear, underneath the tail plane, by a planking of 3 mm. plywood. Suitable formers give the body in front a near circular cross section, the whole body being covered with canvas.

The undercarriage is of the V-type, with solid, streamlined wooden struts and a continuous axle which rests between two

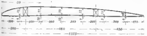
auxiliary axles. The spring range of the axle is not limited in any way.

The tail plane is of one piece and is mounted on the body at an angle of incidence of 1 deg., without the customary incidence-change gear. The elevator is of the divided type, each portion having its own crank with single control leads.



Detailed View of Body in Side Elevation and Plan

The power plant consists of a 110-hp. rotary Le Rhone engine, which is known to have developed 130 hp. in earlier tests. The main fuel tank contains 100 liters of gasoline and the oil tank has a capacity of 21 liters, both are mounted behind the pilot. There is in addition an emergency gravity fuel tank of 26 liters' capacity, which is mounted on the upper starboard wing. The engine is fed from the main tank by compressed air, generated by a small air pump, which is at-



The Wing Section

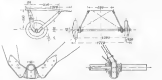
tached to the left forward undercarriage strut. The total fuel supply insures a flight endurance of about two hours.

The following instruments are mounted in the pilot cockpit: to the right, two fuel supply pipes with stop cocks, and a change gear for the elevator control, on the instrument board, tachometer, speedometer, altimeter, spark switch, watch, and compass, to the left, fuel and oil throttles, and a hand pump for the air. Two machines of the same model, which were built by the Aircraft Manufacturing Co., Ltd., London, have the instruments disposed in a much handier manner and are also fitted with an electric lighting system for night flying.

The armament of the D.H.5 consists of a Maxim machine gun, which is synchronized to fire through the airscrew and is mounted on the nose of the machine to the left of the pilot. The control is of the hydraulic type and the release is effected by means of a Bowden cable. The cartridges are carried in a metallic belt and the box into which it runs is fitted directly below the machine gun, behind the engine.

The weight of the machine, empty, is 461 kg., and, fully loaded, is 694 kg. The wing area being 20.14 sq.m., and the horsepower being assumed 130, the wing loading appears to be 34.4 kg./sq.m. and the power loading, 5.33 kg./hp.

The great visual range of this machine is noteworthy, both forwards and upwards, this feature has been achieved by the



Details of Undercarriage

negative stagger of the wings as well as by placing the tanks behind the pilot seat. While this arrangement does not possess any aerodynamic drawbacks for longitudinal stability, it would seem as if the increase of the angle of incidence of the upper wing toward the tips should unfavorably influence transverse stability.

Tubes and Tubular Structures*

By W. W. Hackett and A. G. Hackett

The present decade will pass down into history notorious for many things good and bad. It will be styled a time of improvement in many ways It will be remembered as covering the period of the world's greatest war, but it will also be remembered among all trades appertaining in any way to engineering as the age of progress in the manufacture and manipulation of steel tubing

The section of tubular work in which we are more especially interested at the moment, however, is that which has relation to aircraft construction, and in this paper we hope to deal with some of the main features of this important subject, giving a brief review of the method of manufacture generally employed, of some of the difficulties that have had to be overcome, and of some of the forms of manipulation which it is possible to put upon good quality steel tubing The latter part of the paper will deal with tests carried out on specimen tubes, under various conditions, and jointed together in different ways All that we have to say will apply to seamless steel tubing

How Seamless Steel Tubing Is Made

To commence the manufacture of a seamless tube a solid billet of steel, well hammered and rolled is taken. This billet must be carefully examined for various faults, and any lamination or surface defect removed by chipping, or else the outside of the billet must be turned all over. The usual practice when the latter is done is to turn about ⅝ in. off the diameter of the billet.

The first operation is then to pierce a hole. Two ways of doing this are in general use one is by means of a hydraulic press, similar to the method of piercing shells so common in this country today, and the other by means of a rotary piercing machine The billet, first centered with large shallow holes, is heated to about 1200 deg. C. and fed between rolls having a curved outline and set at an angle which imparts a forward movement to the billet as it is rotated. Great pressure is used (which causes the billet to tend to open along its axis), and the billet is forced against and over a pointed mandrel held on the end of a stout rod, which butts against a bracket at a distance of about 7 ft. from the center of the rolls. A billet, 4 in. diameter by 24 in. in length, will be made in one operation into a tube about 4 ft. to 5 ft. long. The pierced billet is then taken to another machine which is provided with upper and lower rolls having semi-circular grooves of various radii, and by a series of operations is rolled into a tube of the required size. The tube is passed over mandrels to give the required thickness.

A much quicker process of rolling mild steel tubes is by means of Pilger rolls, but for high carbon steel or chrome nickel steel this process has been found to be unsuitable

Cold Drawing

The first operation in the cold drawing mills is that of "tagging," the hollow bloom (as the rough rolled tube is called) being reduced at one end by suitable semi circular tools in a power-forging hammer The tube in the drawing operations to follow will be pulled through the dies by means of the "tag" thus formed. A small hole is also put into the tube at the point where the tag commences, in order to allow acid and water to work through the tube in the subsequent pickling and swilling processes After being "tagged" the tube is annealed, pickled in a bath of acid to remove the scale, and then swilled in clean water Following this, the tube is dried and then immersed in a solution of soap, or in oil, to lubricate it for the drawing operation. It is now ready for drawing

There are two methods of cold drawing in general use One is by drawing down the outside diameter of the tube upon a long bar of uniform diameter and then passing the tube, while on the bar, through rolls fixed in a "reeling" machine, which is similar to that used in the rotary piercing operation In carrying out this method the tube is put on to the bar, which must of necessity be smaller than the bore of the tube to be drawn The tube and the bar are then pulled through a die of hardened steel of such a bore as will give the proper reduction of gage to the tube The tube is gripped on the "tag" by means of "dog" jaws sliding on inclined planes. The "dog" is moved along the draw-bench by hooks which are dropped into the links of an endless chain The chains move at a speed of from 12 ft. to 35 ft. per minute, according to the class of material to be drawn This process of cold drawing permits of a greater reduction of thickness at each draw than can be obtained by the more usual process of plug drawing but is rather harsh on the material, and the expanding of the tubing (already hardened by drawing) to allow the mandrel to be extracted sometimes cause splits and fractures. These are more likely to appear if this process is used after the tube has been drawn to a light gage

The second method is that known as "plug drawing," and is more usually adopted, in this case a short, hardened mandrel is screwed into one end of a long bar This bar is screwed at the other end into a larger piece of steel known as the "back sleeve," which is screwed and fitted with a nut at either end casting of the draw-bench The nut at the back is used for the purpose of adjusting the position of the mandrel in relation to the die

The tube is threaded over the mandrel and the "tag" is passed through the die, which rests against the die plate Immediately the tube is gripped by the "dog" it commences to move, the mandrel at the same time being drawn forward into position by means of a rope or chain A reduction in gage thickness and diameter, with an increase in length, is the result, due to the walls of the tube being drawn down between the mandrel and the die The usual reduction by this method is about a gage and a half per draw on low carbon steel The operation of cold drawing hardens the tube to quite a large extent, and subsequent annealing is necessary

Annealing

A properly annealed tube showing an ultimate tensile stress of about 30 tons per sq. in. should give about 38 tons after undergoing the drawing operation To prepare the tube properly for further cold drawing it is therefore necessary to anneal after every drawing operation, which means it has also to be pickled, washed dried, and lubricated. A hollow bloom 1⅞ in. diameter by 8 in. gage would require nine or ten "draws" to make it into a tube 1¼ in. by 22 in. gage The annealing is carried out in suitable muffles, usually at a temperature of about 600 deg. to 650 deg. C., until before the last "draw," when a temperature of about 850 deg. C. is advisable. In the case of light gage tubes, this should be done by "close" annealing, as the scaling and blistering of a light tube by "open" annealing would be fatal

When a tube has been drawn to about 7/16 in. diameter there is great difficulty experienced in drawing on a mandrel. The usual practice is to finish ⅜ in. diameter tubes and smaller by reducing the diameter only, termed "sinking." The condition of the tube finished in this way is not so good as when finished on a mandrel the strength of the tube being less. From experiments made, tubes from .5 per cent carbon steel finished by "sinking" show about the same tensile strength as tubes from .35 per cent carbon steel finished with the usual "draw" on a mandrel

Chrome Nickel Tubes

The advent of airplanes and airships has given rise to a demand for steel tubing of a higher class than before, tubes of high carbon and alloy steels being called for This has meant careful investigation in order to find the best heat treatment to be accorded in each particular case. The first attempts at drawing chrome nickel steel were scarcely a success and many breakages of mandrels and even draw-benches resulted from the unsatisfactory annealing of these tubes Chrome nickel tubes are now being successfully drawn by the same methods as are used for mild steel tubing—by means of "plug drawing"—but very great care needs to be taken in the annealing

The amount of reduction in gage per draw is less than half that which is usual in the drawing of mild steel, but in spite of this the wear on mandrels and dies is very great.

* Excerpt from a paper read before the Aeronautical Society of Great Britain.

A typical analysis of chrome nickel steel is as follows

Carbon	.3	per cent
Silicon	.16	"
Sulphur	.03	"
Phosphorus	.03	"
Manganese	.45	"
Chromium	1.10	"
Nickel	4.00	"

Such a steel, when air-hardened, has an ultimate tensile stress of about 100 tons, but a low elastic limit to a maximum value of about 70 tons Tempering will raise the yield point and at the same time slightly reduce the ultimate stress. This steel is being much used for airplane axles. One feature that should be mentioned here is the very serious effect of sulphuric or muriatic acid on hardened chrome nickel steel tubing It has the effect of making the material exceedingly brittle It is therefore inadvisable to use acid to remove scale from a hardened chrome nickel steel tube, but the injurious effect of the acid can be almost entirely removed by suitable heat treatment

Acid affects other high tensile steels in the same way, but to a less degree, and has a considerable effect even on mild steel

Section tubing has been extensively called for by airplane designers, and streamline tubing is used to quite a large extent The first streamline tube our company (Aceles and Pollock, Ltd.) were asked to make was designed by Mr. Howard T. Wright in 1908, and is a section that is very near to the recognized standard of today Section tubing, the streamline-shaped tube especially, is much easier to make if straight sides are avoided, as straight or concave sides compel the use of mandrels and add to the difficulty of production There are three ways of making sections from seamless tubing—namely, by drawing, rolling and pressing Pressing is only practicable on fairly short lengths In drawing there is a slight reduction in periphery in passing from the round, but in rolling or pressing it remains the same

Some Difficulties Overcome

It will be useful in this paper to review some of the trouble we have met with in connection with other trades where tubing has been used to a great extent, and to mention some of the failures as the same or similar faults may occur in airplane construction. When the Bowden brake was first used on cycles and motor-cycles the practice followed was to drill the tube near the handle bar lug to allow the cable to pass through, and this resulted in a large number of breakages. This difficulty was overcome by drilling the holes through the lugs, but many accidents occurred before this practice was adopted Under an alternating stress a tube which has been drilled, unless properly reinforced, is very likely to fail A series of running tests on drilled and undrilled tubes has shown that when stressed up to near its elastic limit the undrilled tube has in many cases ten to twenty times the life of the drilled tube It is often the case that the harder the tube the greater the risk of breakage through a hole One way of breaking a hard drawn tube, adopted in tube mills, is either to "nick" the tube on one side with a file or to punch a hole in one side and then break by striking the tube on a block or anvil

Badly Designed Cycle Lugs

Another series of failures was caused by unsuitable lugs Some of those used in the earlier days of motor-cycling had very strong outlets, and case after case of tube failure occurred. The tubing sometimes broke off so cleanly as to give the appearance of having been cut through The broken tubing could be flattened, thus proving it was ductile and in a proper condition for its purpose In order to prove that the fault lay in the excessive strength of the lugs, a series of experiments was carried out a number of years ago A lug, as generally used, was tapered off at one outlet and left strong at the other A piece of tubing of the usual gage and quality was brazed into the lug and the lug firmly secured to a plate The ends of the two tubes were then moved by eccentrics and connecting rods giving a ½ in. movement at a speed of about 400 alternations per min Each time the experiment was tried the tube broke off cleanly close to the thick outlet, whereas the tube at the tapered outlet remained intact

Another interesting test was as follows After brazing the tube into a lug with respectively thick and tapered outlets similar weights were applied to the ends The tube in the tapered outlet bent with an easy curve, but that at the other end bent abruptly close to the thick outlet

It has been proved to the satisfaction of many cycle and motor-cycle engineers that to keep on merely increasing the gage of a tube that appears to be too weak for its work is not always good practice. For instance, take the case of the front fork tube as used on the ordinary cycle. This tube has proved of ample strength for use on the excellent highways of this country, but for Continental roads something better was wanted Some years ago we supplied a large quantity of front forks produced from 19-gage tubes to Russian cycle manufacturers We were asked to increase the thickness to 18 gage, on account of a number of breakages occurring We did so, but matters were not improved, and we were then requested to increase further to 17-gage There was still no improvement, indeed, the number of breakages increased. The forks all broke off where they were brazed into the crown, and we were asked by the Russian manufacturers to help them out of their trouble One way of doing this would have been by using a suitable liner or sleeve, but we tried another method, which proved quite successful We brought back the gage of the tubes to 19 where brazed into the crowns and tapered the gage to 22 at the bottom ends. This proved effective, a lighter article by about 40 per cent, from the same quality steel, thus standing the strain successfully This result is accounted for by the fact that the shock was more equally distributed along the tubing, due to the strength being reduced gradually, away from the brazed portion, whereas in the plain gage tubing the whole of the movement was concentrated in a very small space near the crowns

Tapered Tubes

Tapered tubes could, in our opinion, be used in airplane construction to a much greater extent than at present, especially as struts or spars.

Alternating tests as follows were carried out at 400 revolutions per min. on 1 in. by 20-gage steel tubing, using two parallel lengths and two pieces tapered ½-in per ft. A weight of 111.56 lb. was suspended on each tube at a distance of 12¾ in. from the grips, giving 25 tons stress. The plain pieces broke after 20,585 and 30,390 revolutions respectively, as against 23,557 and 38,225 revolutions respectively by the tapered pieces The weight of the plain tubes was 6¾ oz. each, and that of the tapered tubes 6¼ oz. each. In both cases the break on the plain tubes was straighter than on the tapered one

There are several ways in which to taper a tube A method much in use is that of swaging, but this is a most unsatisfactory way, as the tube is not kept round whilst being reduced Swaging tools cannot be quite circular, as a certain amount of "backing off" must be given to them, or the tube will be pinched and crumpled The continued deforming of the tube during this operation causes it to split if it is much reduced, and the steel is left brittle Tapering is more successful if done on rolls, as it is then possible to keep the tube round, and the steel is left in a much better condition In reducing the tube by tapering it is thickened in gage roughly by about two gages in a reduction of 50 per cent of its diameter A tube of 1⅛ in. by 20-gage would thicken to 18-gage if tapered down to 9/16 in. diameter If uniformity of gage be aimed at it would be necessary to thin the tubing before the tapering operation This can be done by drawing It is even possible to make a tube tapering both in diameter and thickness if such is required

Tubular Liners or Reinforcements

Considerable attention has been given to the matter of liners as reinforcements to tubes In cases of trapped or flattened ends of struts a piece of strip steel is often inserted and soldered or riveted into position This is not good practice, as the tube is not strengthened beyond the point at which it is flattened, and it is well known that, without some additional strengthening, a tube is always weakest at the point where the change of shape begins If, before flattening, a tubular liner of a gage equal to about half the thickness of the piece of strip steel is inserted to extend some distance beyond the trapped portion, a much better result is obtained Various compression tests have been carried out from time to time, and the tubular liner has always proved to be superior

A liner, however, to be really efficient, should be brazed or soldered to the tube A series of alternating stress tests has

proved this point. Many liners used in tubular constructional work are not fixed, and consequently do not prevent the tube breaking, but may be sufficient to avoid accidents resulting from such breakages. Take, for instance, a front fork tube on a motor-cycle. The liner, often a long one, is put in because this tube has frequently failed at the lugs and serious accidents have occurred, but the position of the liner in the fork makes it very difficult to solder or braze in its place. However, if a fork tube should break the liner will save the situation.

It is not wise to make a liner stronger than the tube it is to reinforce unless the ends of the liner are tapered off gradually or weakened by serrations. When the ends are serrated and the liner is not brazed or soldered into the tube this serrated portion is seldom of any value, as it quickly takes a "set" away from the tube when it has been subjected to a bending stress.

Perhaps the better way to reinforce tubular parts is by means of strengthening "sleeves" brazed or soldered to the outside of the tube. Although in appearance not so neat as when an internal liner is used there is the certainty of being able properly to fix the sleeve in position. A drilled tube 1 in. by 20-gage was reinforced by a sleeve (in halves) 2½ in. long by 18-gage thick, pressed into position over the hole. This tube was subjected to an alternating stress test at 400 revolutions per min. The sleeve expanded at the ends under the test and gradually became so "bell-mouthed" as to be of little practical use. The tube fractured across the hole at 9320 revolutions.

Another tube was cut from the same length, similar in all respects, but it had the sleeve soldered in position. This tube did not break until after 43,867 revolutions had been made, and then it failed between the sleeve and the grips.

Another piece of tubing, also from the same length, having a plain hole drilled through and not reinforced at all, failed across the hole after 3684 revolutions.

The following is a tabulation of the results just described:

Sleeve pressed on only	9,320 revs.
" soldered on	43,867 "
Without sleeve	3,684 "

These tests point to the fact that a sleeve merely pressed into position has little value, but that when fixed to the tube by soldering or similar means it acts as an efficient reinforcement.

A number of tests were carried out at the time on laminated tubes, formed by drawing one light tube over another, to take the place of a tube of the same weight as the two combined. Under the few tests made the laminated tubes withstood vibration and shock much better than the plain heavy-gage tube. The only reason we can assign for this is that cold drawing hardens the outside of the walls of the tube more than the center if the tube is a thick one, and by drawing together the two thin tubes to give the same thickness of wall the metal has the benefit of the double drawing operation. Further tests are necessary to prove or disprove this point.

Tube Manipulation

The possibilities of tube manipulation such as butting, tapering, drawing with taper gage, expanding, flanging, bending, lapping, etc., are becoming better understood. Some designers, however, while recognizing the usefulness of these different operations, still ask for what is not commercially possible, because they fail to make allowances for the alteration in the thickness of the tube which will occur as the result of such operations. For instance, if the diameter of a tube is increased the thickness of the wall is reduced, and if decreased in diameter the thickness is increased. Again, if a tube is flanged the flange will not be of uniform gage, but will decrease in thickness as it increases in diameter.

A section of a bent tube cut from an F.E.2b undercarriage "V" strut was then shown. The gage of the tube had by bending been reduced on the outside of the curve from .061 in. to .048 in., and increased on the inside from .061 in. to .072 in. The thinning of the tube would cause it to break if it had not been properly annealed; and, further, if proper mandrels had not been used, or the tubes had not been filled with suitable material, a series of "puckers" or "corrugations" would have been formed on the inside of the bend. Where proper thickening up of the wall along the inner curve takes place in bending the bent portion of the tube is the strongest, but if "puckering" takes place this point becomes the weakest.

Bending is sometimes carried out on steel tubes while in the hot state, but where strength is required this is bad practice, as by heating the tube is rendered much weaker than it would be if bent in the cold state.

Tubular Joints in Aircraft Construction

Generally speaking, structural work for aircraft purposes is today carried out by means of sockets placed in suitable positions and arranged to receive the ends of the various tubular cross-members and bracings. These tubes and sockets are connected in three or four ways—namely, by brazing, by silver-soldering, and by soft-soldering.

Sometimes the sockets or lugs are dispensed with, in which case the cross-tubes are mitred and welded direct to the main tube.

The latter method is not advisable except in very rare instances, as any operation involving great heat is dangerous, owing to the weakening which results from the annealing or perhaps burning of the steel.

Another method is sometimes employed in which cross-bracings are connected by means of a hinge joint to a sleeve on the main tube.

It will be useful to give the results of some comparative tests made on these various methods of jointing tubular structures, but before doing so we would remark that, in a paper like this, only the fringe of the subject can be touched. Everyone who is in any way connected with the practical side of aeronautical construction will readily call to mind many other types of joints, each designed for a special purpose or to overcome a constructional difficulty.

Speaking from an experience of at least eight years, in which we have been in touch with aircraft construction and design, we have met with a surprising amount of fluctuation in the respective popularity of soldering, brazing, welding, etc., for steel tube work, all these methods having been ruled out in turn only again to find favor in certain quarters. This is partly due to the fact that machines designed by private manufacturers have been brought into great popularity and the methods and designs of such makers adopted.

We have seen welding carried almost to excess and then almost abolished. Brazing has been boomed and then decried, and soft-soldering substituted for it—with a different type of lug or joint to allow for the reduced strength of the flux. This again has been deemed unsafe and silver-soldering, or hard-soldering, has risen into prominence, and today one hardly knows which type really is the popular one, as on the machines now being built for war purposes all styles and types of jointing may be found.

One has to realize that in all these methods the human element comes much into play. For instance, it is possible so to weld a joint that it appears to be sound, yet it may be a "fake"—metal being merely laid on and not fused with the surrounding parts. Or, again, the welded joint may be burnt, thus causing a dangerous weakening.

Similarly with brazing, it is possible with care to make a fine type of joint, but the probability is that in a certain percentage of cases overheating will take place and failure result.

We will now deal with the results of a few experiments recently carried out on certain of these types of joints.

Soft-Soldered Joints

Let us take soft-soldering first. In all cases the tests were made with a soft solder composed of 60 per cent tin and 40 per cent lead—using "Fluxite" or some similar article as a flux.

Tubes of various gages were tried, but up to a certain point the strength of the soldered joint was such that the tube failed in tension without the joint giving way.

The strength of a soldered joint is much greater than it is generally supposed to be, and from experiments carried out, the clearance or thickness of the soldering material does not, between the limits of .001 in. and .008 in., make much difference, but for any components that can be guaranteed to size we would recommend as "thin" a joint as possible.

A striking example of a strong joint of the type just referred to was then given. The test on this joint was carried out in order to prove to the satisfaction of inspectors that the stipulated minimum clearance of .005 in. on the diameter was not necessary. In this particular case the elevator lever was held stationary while a torsional load was exerted on the tube. The result speaks for itself.

One of the chief arguments against the use of soft solder is the reduction in strength resulting from vibration, it being claimed that this form of joint will not sustain a vibratory load nor a series of shocks. This may sometimes be right, but even under these conditions a very satisfactory result can be obtained if the sweating is done thoroughly and well, and added strength is given if the joint be "pegged."

Tests on Soldered Joints

The writer recently carried out some experiments on what may be termed a "Tup testing machine" for soldered and brazed joints. The rising and falling tup is actuated by a bell crank lever, worked by a "sudden-drop" cam. The dead load on the tup shaft can be varied by means of a sliding weight. A standard drop of 4 in. was arranged for.

It was at first thought that the effect of the "tup" action would be to quickly rupture the joint, but to our great surprise the joint held to such an extent that we found it necessary during the test to increase the load from 10 lb. to 24 lb. The following are the details of the test:

Size of tube: 1 in. O/d by 18-gage.
Depth in socket (or lap): ½ in.
Thickness of solder: .005 in.
Number of blows: 113,500 with 10-lb. weight tup.
Further number of blows: 64,000 with 24-lb. weight tup.

At this stage the joint showed signs of giving way, so it was decided to apply a tensile test to see if the repeated blows had in any way deteriorated the solder. To our surprise the tube did not pull out until a load of 5.2 tons had been registered, giving the excellent result of 3.31 tons per super inch on the solder lining.

As regards the general results of soldering, the following list of tests will give a good idea of the strength attainable under proper care and supervision.

It may be urged that these results are not a fair basis on which to reckon, as they do not represent the ordinary work of the average operative. In answer, we would say that these results were all obtained from test pieces sweated by different operatives, in some cases being the work of girls with about two months' experience.

It may be possible to work out a formula to arrive at a basis for designers of soft-soldered joints, but even here, as in all calculations relating to structures, other factors have to be taken into account. For instance, a joint may be quite strong enough if on a 1-in. by 20-gage tubular joint the solder reaches to a distance of ½ in., and working on this basis it follows that the same distance for a 2-in. diameter tube of the same gage would be correct, but no one would be satisfied with this, and would naturally double the length of socket to meet the increased diameter.

Generally speaking, it may be taken for granted that with ordinary care, and with a good quality of soft solder, a joint can always be made to withstand a shearing stress of 2½ tons per super inch on the solder itself—provided (and this is the crux of the whole matter) that the articles are well tinned and cleaned prior to the operation of sweating.

As regards the apparatus for sweating, different people will have a different choice, but having tried soldering irons, blow-lamps, coal-gas jets, and hydrogen flame, we have found that the three latter are about equal, and each is better than a soldering iron alone, but this latter is necessary for finishing in awkward corners. Eventually the use of a simple electrical device will probably become popular for repetition work.

Brazing

As previously mentioned, this means of connection still has many adherents. There is, however, a great disadvantage attached to it, viz., the risk of burning the tube owing to the intense heat necessary. That this burning and consequent weakening does take place can be easily shown by the results of tests carried out by us on a cantilever testing machine.

The tests were upon tubes which had been fixed into sockets and brazed or soft-soldered.

Another point may be mentioned with regard to these tests. In one case the joint was "faked," the tube and socket being left dirty and improperly tinned in consequence of which the soldered joint had no "bite." Even under these conditions the joint held for 75,130 revolutions, as against about 4,000 for the brazed joint. At this point the socket failed, due to the insecure fixing of the tube.

Another peculiar feature of this test was the heat generated in the brazed tubes due to the constant working of the molecules. The tubes commenced to warm up almost immediately, and before they broke the temperature of the tubes near to the points of fracture (i. e., near the socket) was about 120 deg. C., sufficient to cause the charring of any adjacent wood, whereas the soldered tubes remained quite cool until the last few minutes prior to fracture.

We are quite aware that in many places on aircraft structures brazing is permissible and good, but where any weakening of a member is likely to cause disaster brazing should be carefully avoided.

Silver-Soldering or Hard-Soldering

The foregoing remarks as to brazing hardly apply to silver-soldering, as by this method a strong joint can be obtained without undue heat. We are not in a position at the moment to give any comparative figures of tests, but we should say that from the standpoint of tensile strength, silver soldering is higher than soft-soldering, and very near to that of brazing. The heat necessary to perform the operation is lower than for brazing, and is not likely to weaken any members if reasonable care is used. It is, however, a longer process, and the material used is very costly.

Welding

We may well ask ourselves in these days where we should be without some form of autogenous welding. The thousand and one articles that are built up of sheet metal welded together speak for themselves, and make us wonder how we ever got on without this useful engineering process.

Still, welding has its limits of usefulness, and if exceeded danger may be near.

In the early days of aeronautical engineering welding was often used in places and on parts where today it is "taboo," and such a method as welding tube to tube has dropped to a great extent out of favor, having been superseded by the more costly but better and safer engineering practice of jointing by means of machined or built-up tubular sockets, previously referred to.

Welding—by whatever means it is done—is always open to a certain amount of doubt, and though there are innumerable cases where this doubt as to the strength of a joint is well covered for, yet, owing to the hidden nature of the defects of welding and the possibility of burning and oxidization, present-day designers avoid it in any important member of an aircraft structure.

A most important rule introduced during recent years has been the suitable annealing of welded joints, and this rule should be adhered to whenever possible. Many will have noticed the brittleness of a welded joint before annealing or normalizing, and the malleability of the same afterwards.

On this point the writers have discovered within the last few months a rather strange fact. We had occasion recently to make up some small lugs, on which a certain amount of shortening took place as the result of the welding on of the arm. We have since noticed this shortening in other tubes, some of quite considerable length, where various fittings have been welded on at intervals, and so far we have not arrived at a satisfactory explanation.

For the sake of any who may not have been able to carry out their own tests on welded joints, it may be helpful if we here give the results of some experiments we have made.

The easiest method of welding is the butt joint—i. e., when two tubes are placed end to end and joined together to form one length or mitred together to form one piece. In such a case the surfaces to be welded are readily accessible, and the flame has freedom for doing its work.

A more difficult type of welding is that necessary when one tube has to be mitred to the outside of another tube, as when forming a "T" lug. In this case the easily melted end of the one tube has to be united to the outside surface of the other, and anyone who has had experience with welding will know how much more difficult it is to attack the hard outside skin of a tube or sheet than it is the edge.

In order to prove this point we carried out tests on tubes measuring 1 in. outside diameter by 20-gage and 1 in. outside diameter by 16 gage—some being butt-welded and others having an interposed tube of about the same diameter, to which the end of each tube was welded.

Comparative tests were made on a cantilever tube joined to the main member by welding, and a similar type of loading

was also tested for a lug, with the tube fixed in place by welding.

The following were the results:

Welded direct to tube	335 lbs
Welded into socket	365 lbs

Welding is often harshly criticized as regards its ability to withstand vibration, but even in this respect we have found striking instances where the tube has broken before the joint.

Some time ago we tried an intermittent shock and vibratory test on a machine. This machine gave a series of vibrations to the tube, the blows due to the "peg-cam" being 1,400 per minute. In some cases the tube broke off without the welded joint suffering in any appreciable manner.

As regards welding of any description to be done on tubing, we do not advocate the use of tubing made from steel too high in carbon. A low carbon steel gives the better result, and it is also most essential that the phosphorous content of both tube and welding wire shall be low.

Wherever possible we would suggest that the welding on of hinges and sockets to a main spar or post be avoided. To slot a tube or soften it by welding is unwise, and in place of any fixtures that at present demand such operations we recommend a sweated and pegged fitting.

Some experiments were carried out by our company in order to convince some of our friends of the advisability of following the course we have suggested. In one case a wiring lug is fixed on a main spar by welding, and in the other by sweating and pegging. Alternating tests on these tubes gave the following results:

Welded	5,190 revs
Soldered	8,800 revs

Rust Prevention

One further point remains to be mentioned. It is well known that a long life for any modern airplane is not expected. The present necessary wastage in aircraft is such that the question of internal rust and corrosion of the steel work is not of serious moment. The time is coming, however, when such matters will have to be seriously considered. For any post-war machines—especially if designed for general passenger traffic—the question of the length of life of the parts will be one of primary importance. Many experiments have been carried out in this country with this end in view, but nothing definite has been reached.

We have experimented with two or three methods of preserving from rust and corrosion with fairly satisfactory results, and in the case of airship framework, subject as it is to salt-water influence, we have used with fair success the "rosletizing" process.

For soldered work, such as rudder and fin frames, we have instituted at our works a thorough system of washing and brushing in hot soda water to remove all traces of the flux or the flux, and we think this is most essential.

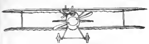
In conclusion, we would say that "the last word" in tubes and tubular structures has not by any means yet been spoken. With the increase in the size of machines, the constant and ever increasing shortage of seasoned lumber, the extended use of machines in future years in hot climates, with all the climatic effects on timber, the "all steel" machine will undoubtedly soon become a reality and a necessity, and consequently the subject of tubes and tubular construction assumes increasing importance.

The Era of Large Aircraft

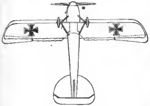
King George Seated in the Pilot Compartment of a Handley-Page Biplane
Photo Press Illustrating Service

Some New Enemy Airplanes

Several new types of German airplanes have made their appearance on the Western front since the launching of the great German spring drive which is now victoriously being rolled back by Marshal Foch. For the success of this offensive the enemy relied on a gigantic concentration of men, guns of all calibres and airplanes of all types. While many of the latter were newcomers in the equipment of the German Air Force, considerable reinforcements were also obtained by stripping the Eastern front of machines of the general purpose



Front Elevation of the Albatros D 5



Plan of the Albatros D 5

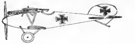
type, such as the Rumpler C III, the Albatros C III, and the L.V.G. C III, which had previously been relegated to Russia on account of their obsolescence.

Of the new types of German airplanes many have lately been brought down by Allied aviators, thus becoming available for detailed examination. The descriptions which follow have been summarized from information appearing in *L'Aérophile*, *The Aeroplane*, *Flight* and *Flying* (London).

Three-Quarter Rear View of the Albatros D 5
Photo Press Illustrating Service

The Albatros D.5

The Albatros D.5 pursuit machine, or single-seater fighter, as the English call it, is a development of the model D.3 of the same firm, placed in commission in the spring of 1917, and derived from the Albatros D.1 and D.2 which first appeared in the battle of Verdun, in 1916. It is noteworthy that there is no record of an Albatros D.4 ever having been captured, so it may be surmised that this model was never used at the front,



Side Elevation of the Albatros D.5

possibly because its trials were unsatisfactory. The principal characteristics of the four known models of the Albatros D-class machines, all biplanes, appear in the following table:

The Albatros Pursuit Machines

Model	D 1	D 2	D 3	D 5
Span upper	8.60 m	8.43 m	9.03 m	9.00 m.
Span lower	8.03 m	8.00 m	8.75 m	8.70 m.
O. A. Length	7.30 m	7.30 m.	7.33 m.	7.30 m.
O. A. Height	2.90 m	2.65 m	2.85 m	2.45 m.
Engine	Mercedes	Mercedes	Mercedes	Mercedes
Power	160 hp	160 hp	160 hp	180 hp
Wing area	25 sq. m	24.50 sq. m.	21.13 sq. m.	20 sq. m.
Weight net			684 kg.	660 kg.
Weight gross			924 kg.	885 kg.

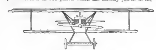
While the Albatros D 5 does not by any means represent the last word in German pursuit machine design, the type having

Cockpit of the Albatros D 5
Photo Press Illustrating Service

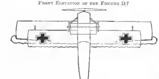
lately been displaced to some extent by the Pfalz D 3, the Fokker triplane, and the D 7 models, the Albatros D 5 is nevertheless interesting on account of the considerable reputation it enjoyed among enemy fighting pilots. Baron von Richthofen's "flying circus"—which the French called the "Tango squadron"—was by the way for a time exclusively mounted on these machines, and it was only a short time before the famous

enemy leader's death that the equipment was changed to Fokker triplanes

The Albatros D.5 resembles outwardly the Baby Nieuport, which is particularly due to the V-type interplane struts of which there is one pair on either side of the body. The planes are of nearly equal span, and are set at a slight positive stagger, without sweepback The upper plane, which alone carries ailerons, is of one piece and is fixed to the body by means of an N-type cabane of streamlined steel strutting; the lower plane consists of two panels which are directly joined to the



Front Elevation of the Fokker D 7



Plan of the Fokker D 7

lower body longitudinals, and not, as is now customary on most enemy machines, to wing roots While the upper plane is rectilinear, the lower plane embodies a slight transverse dihedral

The body is of monocoque construction, being built up of six longitudinals, acting as stringers, and a number of formers, the whole being covered with cloth-covered plywood The cross section of the body is of oval shape, whereas the D 3 had straight sides.

The tail plane and the vertical fin are integrally built with the body formers and are covered with plywood, elevator and rudder, both balanced, are built of steel tubing and are cloth-covered

The engine is a 180-hp Mercedes (new 160-hp) and is covered by a streamlined cowling conforming to the body section, which leaves only the cylinder heads exposed The airscrew carries a small spanner

The armament consists of two Spandau machine guns which are mounted in front of the pilot and fire through the airscrew by means of an interrupter gear

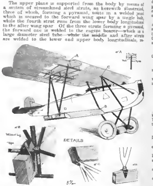
The Fokker D 7

But for the fact that it is a biplane, the Fokker D 7 is very similar in general outlay and constructional details to the well known pursuit triplane of this firm* Like the latter, the Fokker D.7 embodies an abnormally deep wing section, wireless wing design, exclusive use of steel tubing with mostly welded joints in the construction of body, interplane and cabane struts, tail unit, and undercarriage, and, finally, the aerofoil-shaped casing of the wheel axle. The most notable departures of the D 7 from the 1917 triplanes consist in that the engine is a 180-hp Mercedes, as against a 110-hp rotary Oberursel-Le Rhone, and in minor details of the wireless wing design

Both upper and lower planes are in one piece, the spans being 8 93 m, and 7 75 m, respectively, and are heavily staggered The chord of the upper plane, which alone carries ailerons, is 1 60 m. and that of the lower plane is 1 20 so the latter is virtually a geometric reduction of the upper plane. There is no sweepback, nor any dihedral *due to the setting of the wings*, though the decreasing depth of both planes toward the tips actually introduces a slight transverse V into the wing unit

Side Elevation of the Fokker D 7

The upper plane is supported from the body by means of a system of streamlined steel struts, as herewith illustrated, three of which, forming a pyramid, unite in a welded joint which is secured to the forward wing spar by a single bolt, while the fourth strut runs from the lower body longitudinal to the after wing spar Of the three struts forming a pyramid, the forward one is welded to the engine bearer—which is a large diameter steel tube—while the middle and after struts are welded to the lower and upper body longitudinals, respectively Provision is made for changing the angle of incidence of the upper plane by fitting the lower end of the rear inner struts with a threaded eyebolt, so incidence change gear is however provided on the lower plane



Constructional Details of the Fokker D 7
From Flight

The interplane struts are of the N type and are attached to the wing spars by ball-and-socket joints, those for the front top spar and lower rear spar being fixed, while threaded bolts screwed into the strut ends abutting on the upper rear and lower front spars afford means for adjusting the incidence. There are no landing or flying wires.

* See the June 1, 1918, issue of Aviation.

As has been said before, the planes decrease in depth towards the tips, the maximum depth of the upper plane being 0 24 m, while at the tip it is only 0 125 m; the maximum depth of the lower plane is 0.18 m

Unlike on the triplane, where the wing spars were placed so close together as to form a single box, separate box spars are used on the D 7, these are built up of spruce flanges and threeply webs, and taper in a vertical as well as in a horizontal plane.

The wing ribs, which are spaced 0 30 m apart, are similar to those of the triplane,* except that a two-piece flange takes the place of the old grooved one-piece flange and that connection between web and flange is not done by vertical tacking

Instead, the two halves of the two piece flanges are held together and to the thin web by transverse tacks driven through alternately from right to left, and riveted over According to marks stencilled on the wings both planes are set at 0 deg. incidence

The overall length of the machine is 7 02 m, and its overall height 2 80 m. The armament consists of two synchronized Spandau machine guns No information is as yet available on the performances of this machine

(To be continued)

* See the July 13, 1918, issue of Aviation

The Ornithopter*

By Herbert Chatley

There is very little probability that any new form of flying device will be originated during the Great War, since the talents and experiments necessary can be more usefully devoted to the improvement of the airplane. The latter has proved so successful that there is small prospect that any rival could develop to a comparable degree of efficiency in the present environment

Nevertheless it cannot but be of interest once again to consider, in the light of our greatly advanced knowledge on the subject of flight, the problem of the real bird machine. That type promises certain things which it is difficult to conceive the airplane can ever supply, the lack of which constitutes almost its only serious drawback These are —

(1) The ability to rise without large forward speed.
(2) The ability to land without great velocity relative to the earth
(3) The ability to hover

There is also the possibility of a higher efficiency, but this is somewhat uncertain

On the other hand, it seems certain that an ornithopter would have certain undesirable qualities which may prove insuperably harmful These are —

(1) Mechanical complexity.
(2) High structural stresses.
(3) Variable dynamic stability.
(4) Small rigidity in the supporting surfaces
(5) Intermittent support

In spite of the partial success of some flapping models, it is by no means quite clear how wings, properly so called, act The naturalist school differs widely in its opinions, and even the Marey sphygmograph records are not decisive.

There are two types of difficulty —

(1) Ignorance as to the aerodynamic reactions on an oscillating wing
(2) The complexity and continuous change of the mechanical conditions of equilibrium

The first is got over (it may be to some extent incorrectly) by assuming that at any one moment the reactions are the same as would occur in a state of similar but steady motion

As far as the second is concerned, two obvious conclusions occur —

(a) The mean upward thrust must be equal to the weight supported
(b) The mean forward thrust at constant horizontal speed must be equal to the horizontal resistance

The resultant thrust must then be upwards and forwards. It does not, however, wholly necessarily follow that the effective wing stroke must be downwards and backwards, as Pettigrew believed, since the horizontal velocity must be taken into account If the wing moves vertically downwards relatively to the body it will provide a forward thrust component if it slopes downwards and forwards at an angle of a value between certain limits. These limits are difficult to fix The resultant motion of the wing with respect to the air is composed of the vertical velocity relative to the body and the horizontal velocity of the whole machine. In order that there shall be any lift at all the chord plane must make a positive angle of attack with this direction of resultant motion Hence the superior limit to this angle of depression is the direction of resultant motion In order that the drag shall be overcome the resultant force on the wing must have a forward component, and the angle of attack at which this vanishes (i e, the thrust becomes perpendicular) determines the lower limit

On the upstroke the reaction is downwards if the angle of attack is negative, and backwards if the angle of attack is positive Since energy would then be consumed uselessly in either case, I deduce that the angle of attack on the upstroke should be zero—i.e, the wing should run in the wind, which means that the chord plane coincides with the direction of relative motion There is, of course, a small frictional drag downwards and backwards, but this cannot be eliminated. If the upstroke is made in the same time as the downstroke (any increase of speed would increase this harmful skin friction and also change the direction of absolute motion, but nevertheless may be permissible), then during the downstroke the mean vertical force must equal twice the weight, and the mean horizontal forward force must equal twice the mean horizontal resistance. The machine will necessarily fall somewhat during the upstroke, so that the period must be short (there is a suggestion here of a relation between the period and size, but I am not clear what it is), and it may be necessary to take into account the velocities developed during this fall. Such a vertical oscillation is quite apparent in the flight of large birds

Rayleigh has made a brief analysis on these lines, and I developed the argument mathematically some years ago in the Journal of the Junior Institution of Engineers.

A complete investigation must proceed to deduce the proper wing position at all horizontal speeds, and there seems little doubt that there is a general relation between the period, angles of twist, horizontal speed, wing area, span, and weight

Presuming this problem solved and the conditions of dynamic stability are also settled on the lines laid down by Bryan, it only remains to consider whether the fundamental assumption as to the reactions is true, and I have no doubt at all that some modifications must be introduced The following considerations enter into the question —

(1) A purely mathematical one The root of the mean square is not the same as the mean, so that if the velocity varies periodically the mean resistance is not the same as the resistance corresponding to the mean velocity.

(2) The accelerations of the air stream relative to the wing will cause additions, positive or negative, to the reactions

(3) The "wake" will move about in a complex manner, which will cause the addition of a "virtual mass," which may or may not be of importance Fitzgerald has suggested this as a means of assisting sustentation

(4) The rotation of the wing introduces new torques of possibly important amount.

Some light can be thrown on these questions by experiment with oscillating air screws, such as Cooper's, or the fish-tail type used in China and elsewhere for boat propulsion, and with fixed or oscillating airplanes in a pulsating current.

* Courtesy of *Aeronautics*.

Digest of the Foreign Aeronautical Press

Flying (London), July 31, 1918

*Performance of the Hannover Biplane**—The following figures relating to the performance of the Hannover biplane fitted with a 180 hp. Opel-Argus engine are now available:

Service ceiling, 15,000 ft. Estimated absolute ceiling, 16,500 ft. Maximum altitude reached, 14,400 ft. in 39 min. 10 sec. Air endurance, 2¼ hours at full speed and at 10,000 ft. level, including climb.

		Pounds
Weight fully loaded		2570
Military load		545
Loading per sq. ft.		7.29
Loading per hp.		14.3
	m.p.h.	r.p.m.
Speed at 10,000 ft.	96	1450
Speed at 15,000 ft.	80½	1320

	Air Speed, m.p.h.	Engine Speed, r.p.m.	Rate of Climb, ft. p.m.
Climb to 5,000 ft.	65	1495	590
Climb to 10,000 ft.	65	1475	480
Climb to 15,000 ft.	62	1445	190

Aerial Legislation. By Edgar C. Middleton—One may say that aerial legislation comes under three broad headings, international, national and personal. Whatever form the legislation may take in the future it must be of an international nature, defining territorial boundaries, trade routes, commercial and military altitudes, wireless control, police patrol, general flying laws, identification marks, lighting, lighthouses, markboats and salvage, giving jurisdiction in the matters of collision, casualty and aerial rights. Preferably such a body should be Franco-British-American. Necessary as it has been to drive Germany from the seas, yet more must she be kept from any sort of control of the air. For, with its great spaces and limitless boundaries, flying will offer unusual scope to her national characteristics of cunning and treachery.

As far as the present law rules, both private and national rights are valid within the three-mile territorial waters limit. And, also, as a certain aerial authority lays down—there is no legal justification for his ruling—for 2,000 feet of air over and above a man's property. Both these areas will come under national government. But at least 80 per cent. of commercial flying will be in the International Zone. It is unnecessary to emphasize the need for international control of that zone, and more especially as it affects the principal aerial trade-routes round the world. For instance, Lord Montagu's Anglo-Indian air-route London-Leipzig-Tarnopol-Lugansk-Gurief-Bokhara-Peshawar-Calcutta falls within exactly seven different administrations—British, Belgian, German, Russian, Turkestan, Afghanistan and Indian—all with different languages. Imagine the complications.

For general flying the old laws of two converging aircraft steering to the right of one another at a distance of 100 metres, and an overtaking airplane not approaching further than 100 metres on the right or 200 metres on the left of the overtaken airplane, nor turning in across the bows of other aircraft will be useful—if primitive. But the control of the traffic on the fairways is another matter. Congestion in the air spells grave danger. Either the policy of varying altitudes for varying types of aircraft—International for aircraft of 120 m.p.h. or under, up to 6,000 feet; 6,000 to 8,000 feet for commercial craft, with a speed of 120-200 m.p.h., and any altitude over 8,000 reserved for Government craft or battle-planes—will be adopted, or the craft will be divided from one route to another by local wireless control. Prominent identification marks will be necessary in both cases, also an elaborate system of wireless control, and lighting—presumably red to port and green to starboard—for night flying. Otherwise there promises to be a revival of the piracy and privateering of the early sailing days.

The latter falls quite without the scope of national legislation. Only combined action of the nations will keep the skies clear of the menace of the air robber. Certain it is that such local and national laws as may be laid down must be merged into and subservient to the international control. And, for this purpose, one cannot imagine a sounder guarantee for the peaceful development of aviation than President Wilson's League of Nations.

Flying (London), August 14th, 1918

Aerial Transportation. By C. Patrick Thompson—The results of the ... Handley-Page and the Caproni, has lifted the possibilities of aerial transportation out of the rut in which it has lain hitherto, and beyond which the contemporary press conjectures hesitate to venture—that merely of the carriage of mails. That, indeed, may for some time to come prove the limit to which airplane transportation will be put, but the 130 ft. span weight carrying machine now in use on the battle-fronts is a model which will expand and grow from year to year, and is not optimistic prophecy to assume that each year will see that model improve and advance, growing ever bigger, higher powered, more stable, less heavy-flying and more capable of sustaining proportionately heavy burdens than each of its predecessors, of which, for purposes of comparison, we may take the 1918 big bombing plane to be the first. And we shall expand in the development of such construction until conceivably the mail-carrier will be a comparatively small, light and speedy type amid fleets of heavier planes with a cargo capacity of anything from five tons upwards. When one comes to think that already there are planes capable of flying four hundred miles at sixty miles an hour with a load of bombs that a heavy three-ton service truck would be hard put to convey by road at a greater speed than fifteen miles an hour, the prospect of a long-distance cargo-carrier in 1920 does not lie in the realm of extravagant fancy.

In the consideration of these things, however, there project two salient points which more perhaps than any doubts concerning design, construction, or engining, tend to darken the prospect of the future of aerial transportation, and they are the cost of machines for land transport as opposed to the cost of these huge airplanes and the enormous fuel consumption of the latter.

At present, when machines and engines are designed purely from the viewpoint of military efficiency, and cost is more or less a negligible factor, one can but vaguely guess at the future possibilities of cheap quantity production and the design of engines that are economical in fuel at the cost of a certain loss of speed. Yet it is clear that the airplane engine running practically continuously on full throttle will never be anything but a prodigal consumer of fuel. Moreover, by reason of its perpetual vibration at full power, the item of renovation and depreciation will be a considerable one, modified, it is true, by the application of the discoveries of the experimenter in alloys.

Beyond the initial cost of machines and the expenditure on upkeep, and the running expenses, there will be no further important financial outlay to be faced, saving only the rental of landing grounds and the erection of stages. To a great extent these expenses may be covered by the advertisement revenue. For it is certain that these landing places will become great public centres, more especially when news bureaus are established and the latest stop press from five continents is posted up or proclaimed by speaking machines within a few minutes of the winged messenger's arrival.

The opposition to any expansion of aerial transportation to cover a larger field than the carriage of mails is bound to be violent and widespread. The railways are not likely easily to tolerate interference with what they have come to look upon as their prerogatives, and it must be remembered that they are a mighty power before which the aerial syndicates in their infancy may well stand appalled.

For they represent, not merely the few dominating figures in control, but a host of shareholders, workers of all grades, and the rich landowners, for the use of whose ground the railways are paying heavily—in brief, a whole powerful little world. These elements will be resolutely unwilling to encourage the development of the big weight-carrying machine, and we may expect insidious campaigns ridiculing or denouncing the wider aspects of aerial transportation. It will be a continuous struggle against such forces from the very commencement.

* See the July 1 and 15, 1918, issues of AVIATION

News of the Fortnight

The New York to Chicago Air Mail

The test flights of the New York to Chicago airway mail service were brought to successful conclusions last Friday evening and Saturday morning, when both mail pilots safely landed their machines at the Western terminus of the projected route.

Pilot Max Miller, flying a Standard mailplane, landed in Chicago 36 hours and 56 minutes after he took to the air at Belmont Park, New York. He carried 400 pounds of mail. Pilot Miller's flight was not uneventful, for after leaving New York at 7.09 o'clock Thursday morning, Eastern time, he was forced to land on the outskirts of Cleveland, slightly damaging his machine, at 9.20 o'clock that evening. A stiff wind had blown him 150 miles out of his course.

Following an overnight stay in Cleveland, Pilot Miller resumed his flight to Chicago the next morning, arriving at 7.05 o'clock Friday evening. Thus it will be noticed that a considerable portion of the time required for the mail delivery was consumed by the halt in Cleveland.

Pilot Edward V. Gardner was in charge of the second mailplane, a Curtiss machine, and he made his start from Belmont Park two hours after the first machine went up. He arrived in Chicago at 6.30 o'clock Saturday morning, despite continual motor trouble and a forced landing at Westville, Ind., Friday evening on account of smoke and darkness.

The Post Office Department is well satisfied with the result of the test flights last week, for it was expected that the pilots would have more or less difficulty in picking their way for the first time across the mountainous regions over which the mail route lies. The report of the pilots as to the advantages and disadvantages of the way as plotted at present is still to be received and considered.

When in daily operation, which will probably not be attempted for another eight weeks, it is planned that the mailplane will leave New York at 6 a. m., arriving in Chicago at 4 o'clock in the afternoon. The eastward flight will start at the same hour, but will, of course, not be completed until an hour later, because of the difference in time between the two cities.

If the tentative route undertaken in the test flights is permanently accepted, stops will be made at Lock Haven at 8.30 a. m., at Cleveland at noon, and at Bryan, Ohio, at 1.30 p. m. The schedule calls for a speed of 80 miles per hour, which should easily be maintainable unless heavy head winds are encountered. A halt of 40 minutes is to be allowed at each of the three landing stations for oil and gas.

The entire distance of the air mail will be 745 miles, divided as follows: New York to Cleveland, 418 miles, Cleveland to Chicago, 322 miles, and about landing fields, 5 miles.

The report of the test flights is awaited with interest, as Second Assistant Postmaster General Otto Praeger has declared that the air mail would only be established if the trip can be undertaken every day in the year, and that the schedule will not be disarranged by storm, sleet or snow.

"We must be guaranteed that the route will be a complete success before it is established," said Mr. Praeger. "The record for the Washington to New York trips shows 100 per cent. efficiency for August. No time was lost on any of the trips, and, if established, we expect to see the New York to Chicago route equal this record.

"The postage rate will be the same on all the routes, that is, 16 cents for the first ounce and 6 cents for every additional ounce.

Next spring we will instal a night service, when machines will leave New York at 9 o'clock in the evening with the heavy afternoon mail, and arrive in Chicago the next morning in plenty of time for the first morning delivery.

"The New York to Chicago route," Mr. Praeger added, "will be the last air mail route installed by the Post Office Department until the end of the war."

Pilot Miller started on the return trip from Chicago back to New York early Monday morning. He made a landing at Cleveland, after his plane had developed radiator trouble, making the run from Chicago in 3 hours and 10 minutes. He was delayed at Cleveland for two hours, but resumed his flight, and reached Lockhaven, Pa., where, owing to more radiator trouble, he remained over night. He left there at 9 a. m. Tuesday and arrived at Belmont Park at 11.22 a. m.

He carried 2,000 pieces of mail. After a short rest he began a flight to Washington.

Pilot Gardner reached Belmont Park late Tuesday night. He encountered foggy weather.

Mr. Baker and Mr. Ryan in France

The arrival of Secretary of War Baker in France on his second visit to the fighting front was announced in Washington on Sept. 9.

He was accompanied by John D. Ryan, Second Assistant Secretary of War and Director of the Air Service, Major Gen. William C. Gorgas, Surgeon General of the Army, Brig. Gen. Frank T. Hines, Chief of the Embarkation Service, and Lieut. Col. George H. Baird, Military Aid to the Secretary of War.

Mr. Baker and the official party made the journey on an army transport which carried the usual quota of United States troops. The duration of Mr. Baker's stay in France is given as "some weeks."

Mr. Ryan went to France primarily to familiarize himself with the Air Service under actual fighting conditions. It is his first trip to France since his appointment as Director of Aircraft Production. One serious difficulty with which the Air Service of the army is the great distance which separates the field of active operations from the production facilities in this country. Orders sometimes come from France which are countermanded in process of execution. To bring about closer cooperation between the Air Service in France and in this country is the immediate purpose of Mr. Ryan's visit.

Aerial Postal Service for Norway

An aerial postal service for Norway has been undertaken as a private enterprise. A company with a minimum capital of $670,000 and a maximum of $1,340,000, guaranteed by several Christiania banks, has been formed for this purpose. It is announced that the service will probably include the transportation of passengers, besides carrying the mail for that country.

The airplane route is planned to be from Christiania along the southern and western coast of Norway to Christiania, Stavanger, Bergen and Trondhjem. The time required to cover the distances is calculated to be: Christiania to Stavanger, 4½ hr.; Stavanger to Bergen, 1½ hr.; Bergen to Trondhjem, 4 hr. Another route overland, direct Christiania to Bergen, will require 2¾ hr. These estimates are considered very conservative, and are based on the speed developed by airplanes before the war rather than on that made by machines at the present time.

From Stavanger a route is to be established to Aberdeen, Scotland, which distance is to be covered in 4½ hr.; while Lieut. Trygve Gran in 1914 flew that distance in 4 hr. 10 min. with an 80-hp. Blériot monoplane.

The plan is to equip twenty-eight Norwegian marine flying boats of 200 hp., each having a carrying capacity of 1760 lb. The topographical conditions, the fjords and mountains, make the building of railroads expensive and their maintenance costly.

In contrast with an aerial service, it is pointed out that most of the traffic there is now carried on by steamers along the coast and up the fjords, and therefore is necessarily slow. Stavanger, particularly, is placed at great disadvantage due to its location. A minimum of 24 hr. is required for mail and passenger service between Stavanger and Christiania, although the distance in a straight line is less than 200 miles.

Oxygen Device Tested

Tests of the oxygenizing apparatus for aviators in high altitudes made here have brought unusual results, according to an announcement made by Albert C. Clark, an Illinois state senator, producer of the device.

Senator Clark has ascended with Lieut. Jack Foote and attained an altitude a mile higher than the 11,642 ft. which Lincoln Beachy reached in August, 1911.

Senator Clark said the apparatus weighs about 3 lb. and regulates automatically the supply of oxygen according to the altitude.

Record for August Air Mail

During the month of August the Air Mail Service between Washington, Philadelphia and New York was conducted without a miss, hitch or serious delay of any character.

The operations for the month were perhaps the most remarkable in the history of aviation. There were 27 flying days, of which 108 legs of the journey had to be performed, and in that month there were but two forced landings, one with a delay of 7 minutes and the other with a delay of less than 10 minutes. One forced landing was made within 4 miles of Belmont Park at the end of a journey. It was caused by the break of a magneto shaft. The other forced landing was made on a flight where fog and haze obscured the ground, and for the purpose of picking up the course, because the compass failed to work.

The total possible miles of flight was 11,961, of which 11,957 miles were completed.

During the first 10 days of the month the routes were flown by Lieutenants Edgerton, Kilgore, Bonsal, Webb, Culver and Miller without a miss, hitch or forced landing. During the last 20 days of the month the civilian aviators of the Post Office Department operated the routes. The perfect scores were made by Aviators Max Miller and E. V. Gardner. Aviators Maurice Newton and Robert Shank, on the Philadelphia end of the route, each had one forced landing, giving them a score of 90 per cent.

A total of 5,679 lbs. of mail were carried on the trips.

A most rigid mechanical maintenance system on all fields was maintained, with the result that the month closed without a single plane of the 15 being laid up in the shop for repairs.

Castor Bean Crop in Texas

It is shown by a survey that has just been made of the castor bean crop in Texas by representatives of the United States Department of Agriculture that there are more than 13,000 acres in cultivation and that a good yield of the bean is promised.

In the more southern part of the State harvesting the crop will be started soon. The Government will take over the entire production of engine oil produced from the beans. The success that has been met in growing castor beans in Texas shows that the soil and climate are splendidly adapted to the new industry, the Government experts say, and there promises to be a big increase in the acreage next year.

With the development of the airplane for war use and as a means of general aerial transportation after the war, demand for castor oil as a lubricant for the machines will continue to grow, it is stated. For high altitude flying no other kind of lubricant fills the bill as well as castor oil, according to tests that have been made.

Night Photos from Airplane

An Italian invention which permits photographs being taken at night has been submitted to the Signal Corps of the United States Army.

According to the men who control the new device, it will soon be possible to take excellent pictures of enemy positions from airplanes flying at a low height on moonlight nights. It is also claimed that the invention can be fitted to moving picture cameras, which would permit the photographing for the screen the actual fighting, much of which takes place in the early morning hours.

Up to the present time one of the chief obstacles met by the daylight aerial photographers is that the anti-aircraft guns force the fliers to take pictures from a great height, and much of the detail of the enemy lines is therefore lost. It is held that fliers are in little danger from artillery when flying at night.

Canadian Naval Air Service

C. C. Ballantyne, Dominion Minister of Naval Service, announced Sept. 5 the establishment of the Canadian Royal Naval Air Service, and declared that, thanks to America's aid, "machines are flying along the Atlantic coast, ready to bomb hostile submarines, escort convoys and perform other services."

The United States, he said, had "generously consented to supply the personnel for Canada's Royal Naval Air Service until such a time as a Canadian personnel could be properly trained to take their places."

Also, he said, the United States had supplied the necessary machines, which included airplanes, airships and kite balloons.

Aircraft Production Service Insignia

Nearly 1,200 civilian employes of the U. S. Aircraft Production Service, both men and women, in the city of Washington alone, are wearing insignia in the form of buttons or pins which designate them as individuals who are doing their part toward winning the war in the same degree as those who have actually gone to the front.

All employes of either factories or offices working on aircraft are entitled to wear them, and the total number bought for distribution was between 40,000 and 50,000. They are given as a badge of honor to show that the wearer has a direct personal interest in the speedy production of properly made equipment.

The insignia has a target in red, white and blue, such as appears on each airplane wing. The target, a pair of wings and the letters "U. S." support ribbons bearing the words "Aircraft Industrial Service, Army and Navy."

It is especially noted in issuing these buttons and pins that they are not to be used as a means of identification or as a pass, but as a mark of honor, the same as the uniform.

New British Airplane

English newspapers are giving prominence to a report of a new type of British airplane, which, having been tested at the front with the greatest success, is about to be employed there in large numbers.

No technical details are given, but it is said the new machine has enormous speed and climbing power. It is capable of carrying great weight in bombs, machine guns, and other equipment, and of attaining a height of 20,000 feet in an astonishingly short time.

It is said the machine can cover long distances at a speed which leaves all but the fastest modern scouting machines far behind, and thus is able to cross the enemy's lines and drop bombs and return for a fresh load within a time limit far less than any of the earlier airplanes.

The engines of the airplane are declared to be so completely reliable that risk of compulsory descent into the enemy's territory is virtually eliminated. It is added that not one of these wonder machines has as yet been downed, notwithstanding the utmost efforts of the Germans.

Air Service Medical Corps Created

For the care and conditioning of fliers in the Air Service, the United States Government is now appointing a corps of doctors and trainers large enough to equip each training field and camp for fliers, both in the United States and in France, with a proper organization. The doctors will be known as flight surgeons and the trainers as physical directors.

The medical branch of the Air Service is not alone confined to the selection of the flier, but to his care and condition after he has been admitted to the service. It has become apparent that the flier is unlike other soldiers. In the Air Service he has become an intricate, highly sensitized piece of mechanism with troubles all his own. To keep his complex organism physically fit, a special master mechanic had to be provided solely for him.

The physical directors are assistants to the flight surgeons and their duty is to supervise such recreation and physical training of the fliers as is considered necessary.

"Zenith Patriotic Series, 1918"

Very striking is the "Zenith Patriotic Series, 1918," issued by the Zenith Carburetor Co. of Detroit, Mich. Quotations from Thomas Paine, Patrick Henry, Abraham Lincoln and Woodrow Wilson printed on single sheets in a deep red and enclosed in an impressive cover form the series. Paine is quoted as follows: "Tyranny, like hell, is not easily conquered, yet we have this consolation with us, that the harder the conflict, the more glorious the triumph."

Airplane Ambulances at All Fields

Airplane ambulances for carrying injured airmen quickly from the scene of accident to the nearest field hospital are to be provided at all the Air Service flying fields. Successful experiments with the ambulance airplane at Gerstner Field promptly led to their introduction at nine fields in Texas and the War Department now announces that all field commanders have been instructed to follow the example.

WITTEMANN-LEWIS AIRCRAFT COMPANY

NEWARK, N. J.

Main Office and Factory:

Lincoln Highway near Passaic River

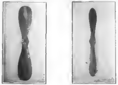
Telephone, Market 9096

Thomas

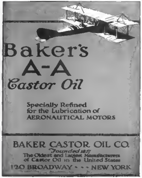
THOMAS-MORSE AIRCRAFT CORPORATION

ITHACA, N.Y. U.S.A.

Contractors to U. S. Government



For Airships For Airplanes



Aeronautical Trade Directory

AVIATION AND AERONAUTICAL ENGINEERING will furnish information and addresses of companies listed below.
Names of Advertisers in this issue are printed in capitals.
See Index to Advertisers on page 264

ACCESSORIES AND INSTRUMENTS

Advance Felt Specialty & Cutting Co.
International Aeronautical Instrument Corp
Johns Manville, H. W. Co
King, Julius, Optical Co.
The Moto Meter Co
National Gauge & Equipment Co
Nelson Blower & Furnace Co
O'Hara Waltham Dial Co.
Queen Gray Co
Risker, Walter
Sperry Gyroscope Co
Standard Aeronautical Co
Stewart Warner Speedometer Corp.
TAYLOR INSTRUMENT COMPANIES
VEEDER MFG CO
Western Electric Co.

AIRPLANES

Aeromarine Plane and Motor Co
Blackhawk Airplane Co.
Blanchard Radley Aircraft Co
Boeing Airplane Co
Breese Aircraft Corp.
THE BURGESS COMPANY
California Aviation Co.
Continental Aircraft Corp
CURTISS AEROPLANE & MOTOR CORP
DAYTON WRIGHT AIRPLANE CO
Des Lauriers Aircraft Corp.
Dewey Aeroplane Co.
Engel Aircraft Co.
Fisher Body Corp.
Fowler Airplane Corp.
Gallaudet Aircraft Corp
Heinrich A. S. Corp.
Lassiter Aircraft Co
Lawrence-Lewis Aeroplane Co
Lawson Aircraft Corp
Lewis & Vought Corp.
Lanzius Aeronautical Eng. Corp.
Longren Aeroplane Co.
L. W. F. ENGINEERING CO
Mortie Aeroplane Factory
MARTIN GLENN L. CO
Michigan Aircraft Corp.
Ordnance Eng'ring Corp.
Patterson Aeroplane Co.
Peirce, Sam'l R., Aeroplane Corp.
Smith, Kyle, Aircraft Co
Sperry Lawrence, Aircraft Co
Springfield Airplane Co
STANDARD AIRCRAFT CORP.
Sturtevant Aeroplane Co.
THOMAS MORSE AIRCRAFT CORP.
The Willys-Morrow Co.
WITTEMANN-LEWIS AIRCRAFT CO
Whittemore-Hamm Co.
WRIGHT MARTIN AIRCRAFT CORP

AIRPLANE ENGINES

Aeromarine Plane and Motor Co.
Ashmusen Mfg. Co.
Continental Motors Co.
CURTISS AEROPLANE & MOTOR CORP
Detroit Gas Turbine Corp.
DUESENBERG MOTOR CORP.
General Ordnance Co.
General Vehicle Co.
Gyro Motor Co.
HALL-SCOTT MOTOR CAR CO.
Kemp Machine Works.
Kessler Motor Co
Knox Motors Co
Nordyke & Marmon.
Packard Motor Co
Roberts Motor Mfg. Co.
Rolls-Royce, Ltd.
Springfield Motors Co.
Sterling Engine Co.
Sturtevant, B. F., Co.
Trego Motors Corp.
THOMAS - MORSE AIRCRAFT CORP
UNION GAS ENGINE CO.
Van Blerck Motor Co.
Willys-Overland Co.
WISCONSIN MOTOR MFG. CO.
World's Motor Co.
WRIGHT MARTIN AIRCRAFT CORP

AIRPLANE PARTS

Aircraft Parts Mfg. Co.
American Body Co
Astoria Veneer Mill & Dock Co.
BARCALO MFG CO.
Century Telephone Construction Co
Chicago Aeronautical Supply Co.
Dayton Metal Products Co
ERIE SPECIALTY CO.
GENERAL BAKELITE CO.
HOLBROOK CO
Kawneer Mfg Co
Levett Walker M., Co.
New Jersey Veneer Co
Pressed & Welded Steel Products Co
Rogers Construction Co
Standard Parts Co.
Welch Mfg. Co
Whittemore-Hamm Co.
WIDMAN, J. C. & CO.
Willys Morrow Co
Wilson Cabinet Co

ALUMINUM

Acieral Co of America
ALUMINUM CASTINGS CO
ALUMINUM CO OF AMERICA
American Metal Co., Ltd.
Levett, Walker M., Co.
Laygrand & Co
McAdamite-Aluminum Co.
SO-LUMINUM MFG & ENG CO (SOLDER)
STIMPSON, EDWIN B., CO.
United Smelting & Aluminum Co.

AVIATION SCHOOLS

American School of Aviation
America Trans-Oceanic Co.
Atlantic Coast Aeronautical Station
Lam Airplane Co
Blackhawk Airplane Co
Curtiss Training Schools
EAGLE AVIATION SCHOOL
The Hydroaircraft Co.
Michigan State Auto School
Moler Aviation Instructors
Penn. State School of Aero-Mechanics
Stinson School of Aviation
Whittemore-Hamm Co.

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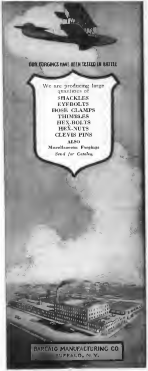

Aeronautical Trade Directory—*Continued*

BALL BEARINGS
THE FAFNIR BEARING CO
Gurney Ball Bearing Co
HESS-BRIGHT MFG. CO
NEW DEPARTURE MFG CO
NORMA COMPANY OF AMERICA
S. K. F. BALL BEARING CO
U. S. Ball Bearing Mfg. Co.

BALLOONS: DIRIGIBLES
Burdette Oxygen Co.
Connecticut Aircraft Co.
Custer Specialty Co. (Statoscope)
Cox Engineering Co. (Gas Plants)
GOODYEAR TIRE AND RUBBER CO
United States Rubber Co.

BAROGRAPHS AND BAROMETERS
Green Henry J
International Aeronautical Instrument Corp.
Seasfeld & Lorch
TAYLOR INSTRUMENT COMPANIES

BEARING METALS
ALUMINUM CASTINGS CO
American Bronze Corp
FAHRIO METAL CO.
Levett, Walker M., Co.
Magnolia Metal Co

BUSHINGS
ALUMINUM CASTINGS CO
American Bronze Corp
Bound Brook Oil-less Bearing Co.

CARBURETORS
A & N Mfg. Co.
Master Carburetor Co.
Miller Carburetor Co.
Stromberg Motor Devices Co.
Wheeler & Schebler
ZENITH CARBURETOR CO.

CLOCKS AND WATCHES
Chelsea Clock Co
Depollier, J., & Son
Hamilton Watch Co
Ingersoll, Robert H., & Bros.
Waltham Watch Co.

CLOTHING
Abercrombie & Fitch
Cross, Mark
N Y Sporting Goods Co.
Rainwear Co.
Rogers, Peet & Co.
Sanders Company
Spalding, A. G., & Bros.

COMPASSES
Sperry Gyroscope Co
Star Compass Co.
TAYLOR INSTRUMENT COMPANIES

DOPE AND VARNISH
Adams & Elting Co.
American Emaillite Co.
Brooklyn Varnish Mfg. Co
CERTUS COLD GLUE CO
Chemical Products Co
Conover, The C. H., Co
Du Pont Chemical Works
Flexible Compound Co.
Harland, Wm., & Son
Howe Varnish Co
Lucas, John Company
Masury John W. & Son
Perry Austen Company
PRATT & LAMBERT
SHERWIN WILLIAMS CO
Smith, Edward, & Co.
Standard Varnish Works
Valentine & Company
Weeks & Co.

DRIFT INDICATOR
Sperry Gyroscope Co

DRY KILNS
Cutler Dry Kiln Co.
DRYING SYSTEMS, INC.
GRAND RAPIDS VENEER WORKS

DYNAMOMETER
Sprague Electric Works

ENGINE PARTS
Allegheny Forging Co.
ALUMINUM CASTINGS CO
Anderson Forge & Machine Co
BARCALO MFG CO
Brooks Machine Co
Burd High Compression Ring Co.
Crosby Steam Gage & Valve Co.
Dalzell, Thos. H., Co.
DOEHLER DIE CASTING CO
ERIE SPECIALTY CO.
Fibre Finishing Co.
Gifford, Leland, Co.
Gill P. B., & Sons
Heyns Mfg Co.
Hydraulic Pressed Steel Co.
Levett, Walker M., Co.
Meisel Press Mfg. Co
PARK DROP FORGE CO
Pressed & Welded Steel Products Co.
Standard Parts Co.
STIMPSON, EDWIN B., CO.
Taft Peirce Mfg Co
Tioga Steel & Iron Co.
Williams, J. H. & Co
Whitman & Barnes Mfg. Co.
WYMAN-GORDON CO.

ENGINEERING
Automotive Engineering Co
Ordnance Engineering Co.
White, J G, Engineering Corp.

FABRICS
Courtrel Mfg Co
Hutchinson, Scott Co
Lamb Finlay & Co.
McBratney, Robt., & Co.
Whitman, Clarence & Co

FELT
Advance Felt Specialty & Cutting Co
Booth Felt Co
Western Felt Works

FIRE EXTINGUISHERS
Fyr-Fyter Co
Johns Manville H W Co
Pyrene Mfg Co.

GAGES
Advance Felt Specialty & Cutting Co.
BOSTON AUTO GAUGE CO
Crosby Steam Gauge & Valve Co.
FOXBORO CO., INC.
Greenfield Tap & Die Corp.
United States Gage Co.

GASKETS
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Fibre Finishing Co

GLUE
Armour Glue Works
Barder & Adamson
CERTUS COLD GLUE CO.
FERDINAND L. W., & CO
WHITMAN J. C. CO

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HARDY, F. A., CO.
Meyrowitz, E. B.
STRAUSS & BUEGELEISEN
Strauss, Sonnard & Sutt
Simplex Safety Glass Corp.
Willson, T. A., & Co., Inc.

HANGARS
American Bridge Co.
Anchor Corrugating Construction Co.
Ashley Steel Bldg. Co.
Austin Co., The
Dusey, John M.
Lowell, Field & Goddard, Inc.
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Milliken Brothers
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Chelsea Lumber Co.
Delatour, J.
Dutton, A. C., Lumber Corp.
Ludlow, Israel
Mengel, C. C., & Bros. Co.
New Jersey Veneer Co.
Shaip & Vandergrift

LUMINOUS COMPOUND
COLD LIGHT MFG. CO.
Cummings, W. L., Chemical Co.
RADIUM DIAL CO.
RADIUM LUMINOUS MATERIAL CORP.

MACHINERY, METAL WORKING
DALTON MFG. CORP.
DEFIANCE MACHINE WORKS
FOX MACHINE CO.
Warner & Swasey Co.

MACHINERY, WOOD-WORKING
Curtis Machine Corp.
DEFIANCE MACHINE WORKS
Fay, J. A., & Egan Co.
FOX MACHINE CO.
Machinery Merchants, Inc.
MATTISON, C., MACHINE WORKS
Oliver & Warren
PRYIBIL, P., MACHINE CO.
YATES, P. B., MACHINE CO.

MAGNETOS
Berkshire Magneto Corp.
Bosch Magneto Co.
ERICSSON MFG. CO.
Remy Electric Co.
Splitdorf Electrical Co.

MANIFOLDS
AJAX AUTO & AERO SHEET METAL CO.
Pressed & Welded Steel Products Co.

METALS
Aeteral Co. of America
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American Vanadium Co.
Bethlehem Steel Co.
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Federal Pressed Steel Co.
Garland Ventilator Co.
Garder, Paeschke & Frey Co.
Kawneer Mfg. Co.
La Salle Steel Co.
Levett, Walker M., Co.
Rumford Metal Co.
SO-LUMINUM MFG. & ENG. CO.
Standard Alloys Co.
Steel Sales Corp.
Steel Products Co.
STIMPSON, EDWIN B., CO.
Wheeler, Frank B., & Son

MODEL AIRPLANES
Ideal Aeroplane Supply Co.
Wading River Mfg. Co.

MOTORCYCLES
Excelsior Motor Mfg. Supply Co.
HENDEE MFG. CO.
Harley Davidson Co.
Militaire Motor Vehicle Co. of America

OILS AND LUBRICANTS
Baker Castor Oil Co.
Graphite Lubricant Co.
Gulf Refining Co.
Sheppard Ideal Oil Co.
Sun Co., The
Standard Oil Co.
Swan & Finch
Texas Co., The
Vacuum Oil Co.
WAKEFIELD, C. C., & CO., LTD.

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Booth Felt Co.
Fibre Finishing Co.

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Herbert & Huesgen Co.

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Levett, Walker M., Co.

PISTON RINGS
American Piston Ring Co.

PONTOONS
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PALMER SIMPSON CO.
Welin Marine Equipment Co.

PROPELLERS
AMERICAN PROPELLER & MFG. CO.
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Aviators Mfg. Co.
Breitung & Co., Ltd.
C. M. O. Physical Laboratory
Doyle, W. A.
Hartzell Walnut Propeller Co.
JACUZZI BROS.
Jamestown Propeller Co.
Lang Propeller Co. of America
Sloves Sash & Door Co.
Reinforced Propeller & Insulating Co., The
United States Aero Propeller Co.
Washington Aeroplane Co.
WEST WOODWORKING CO.

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Aeronautical Trade Directory—*Continued*

PYROMETERS
FOXBORO CO., INC., THE
MOTO-METER CO
Shore Instrument & Mfg. Co.
TAYLOR INSTRUMENT COMPANIES

RADIATORS
AJAX AUTO & AERO SHEET METAL CO
A-Z Co.
Bush Mfg. Co
E Aero Radiators Co.
English & Mersick Co.
FLEXO MFG CO
Harrison Radiator Co
Livingston Radiator Co
McCord Mfg Co
ROME-TURNEY RADIATOR CO
Standard Roller Bearing Co

RIVETS
STIMPSON EDWIN B. CO.

SCELEROSCOPE
Shore Instrument & Mfg Co

SHEET METAL FITTINGS
BLUM, JULIUS & CO.
Rogers Construction Co

SHOCK ABSORBERS
DURAL RUBBER CORP.
General Rubber Goods Co.
Ohio Rubber Co
Russell Mfg Co
WOOD J. W. ELASTIC WEB CO.

SPARK PLUGS
Bosch Magneto Co
Champion Ignition Co
Johns-Manville H. W. Co
Rajah Auto Supply Co
Silvex Co., The
Splitdorf Electrical Co.

SPEED INDICATORS
FOXBORO CO., INC.
Johns-Manville H. W. Co
Stewart-Warner Speedometer Corp.

STABILIZERS
Greene Aeronautical Co.
Martin Aerodynamic Stabilizer.
Sperry Gyroscope Co

STAMPINGS
BLUM, JULIUS & CO.
Enameling & Stamping Corp of New York
LANSING STAMPING & TOOL CO.
Dewes Co., The A
STIMPSON EDWIN B., CO.

STARTERS
Bijur Motor Lighting Co
Bosch Magneto Co
CHRISTENSEN ENGINEERING CO THE
Dayton Engineering Laboratories Co.
ROTOR-COMPRESSOR CO
Northeast Electric Co.
Remy Electric Co
Wagner-Boyt Electric Co.

TANKS
Janney Steinmetz & Co.

THERMOMETERS
FOXBORO CO., INC., THE
MOTO-METER CO
TAYLOR INSTRUMENT COMPANIES

TIRES AND RUBBER
DURAL RUBBER CORP
GOODYEAR TIRE & RUBBER CO.
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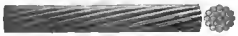

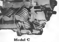
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